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STRANGE HABITS OF FAMILIAR MOTHS AND BUTTERFLIES

By William Joseph Showalter, Sc.D.

July, 1927

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July 1927

STRANGE HABITS OF FAMILIAR MOTHS AND BUTTERFLIES

By William Joseph Showalter, Sc. D.

Author of "Exploring the Mysteries of Plant Life," "Exploring the Glories of the Firmament," etc., and Co-author of "The Family Tree of the Flowers" and "Familiar Grasses and Their Flowers," in the National Geographic Magazine

With Natural Color Illustrations by National Geographic Society Staff Photographers

THE order of insects made up of the butterflies and moths is one of the most fascinating of all the orders of living creatures. Its members range in size from the magnificent Swallow-tail butterflies and Cecropia moths, with wing-spreads of many inches, to the tiny leaf-mining Nepticula, measuring less than an eighth of an inch from tip to tip; in beauty, from the resplendent Peacock butterflies and Luna moths to the drab clothes-moth; in larval form, from the hairy, woolly bears and naked hickory horn devils to the grublike wood borers; in feeding habit, from the nectar-sipping Fritillaries to the aphid-eating Harvesters; in habitat, from the highest mountains and the coldest polar areas to the lowest plains and the hottest equatorial regions; and in relationship to man, from the beneficent silkworm to the destructive cutworm and the tree-destroying Gypsy moth.

BUTTERFLIES SERVE BEAUTY; SOME MOTHS WREAK HAVOC

About 9,500 species of butterflies and moths are to be found in North America. Of these only 650 are butterflies.

Only a few species of butterflies have become pests, most of them being as harmless as they are beautiful. They are a very compact, closely knit group of insects, showing their comparatively recent origin.

On the other hand, the moths disclose a remarkable diversity of appearance, habit, and habitat. Large groups of them exact a tremendous toll of field, orchard, garden, and lawn, and levy heavy tribute upon the Nation's shade and ornamental trees.

In the orchard their caterpillars attack alike blossom, foliage, fruit, wood, and root. In the garden they prey alike upon stalk and vegetable. In the field tender shoot, growing plant, and mature grain suffer at their hands. Some invade flour mills and clothes closets, others quarter themselves in ant nests and beehives. But of the thousands of species not more than 100 are pests.

A few aberrant species have wingless females and others have clear wings, linking them closely in appearance with the bees (see Color Plate X, figures 3 and 5) and the wasps. So thoroughly do some of the latter imitate the bees and the wasps, both in habits and in appearance, that man and bird alike usually give them that wide berth which is accorded the stinging tribe.

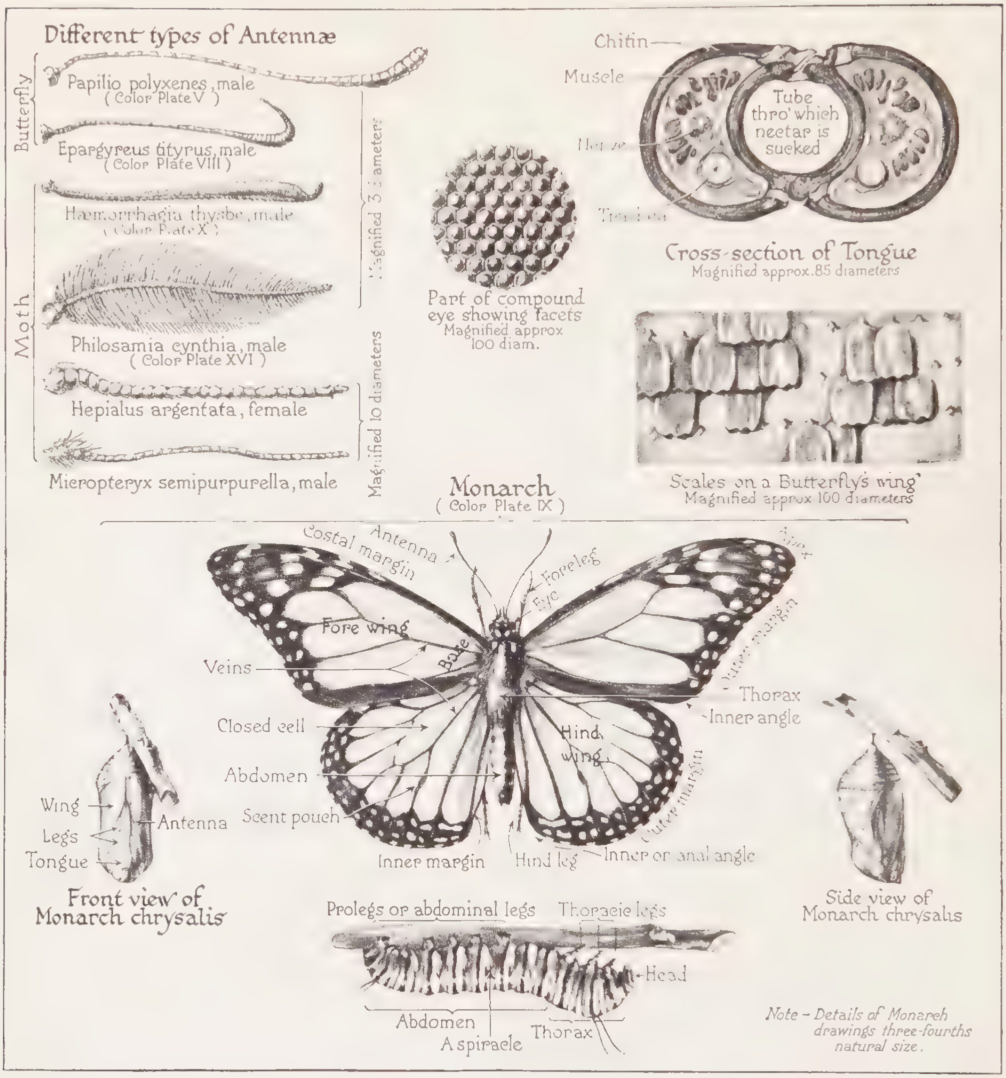
There are two small families, known as the Jugate moths, which form the "missing link" between the primitive insects and the full-panoplied moths and butterflies.

The primitive insects had two pairs of wings equal in size and function. As they have come down through the geological ages, some of them, like the bees and wasps, have thrown the flight functions on the fore pair of wings, and others, like the locusts, crickets, and beetles, have turned the task of flight over mainly to the hind pair. A third group, the Diptera, make no use whatever of their hind pair of wings; so Nature took these away entirely. The Jugate moths carry a striking reminiscence of this change. Like the caddis flies, their two pairs of wings are tied together with a jugum.

IN WHAT PARTICULARS MOTHS AND BUTTERFLIES DIFFER

There are many obvious differences between moths and butterflies.

The butterflies wear knobs on the ends of their antennæ, while the moths, with such few exceptions that the average amateur will never encounter one, lack



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Drawing by Hashime Murayama

THE ANATOMY OF A BUTTERFLY AND ITS CATERPILLAR

The details at the left in the upper half of the illustration show the different types of antennæ occurring among butterflies and moths. The greatly magnified section of a Monarch butterfly's wing (right center) shows how the scales (see also lower portion of Color Plate I) are attached to the wing surface by a sort of stem to a socket. The nodules are the sockets from which scales have been brushed away.

these knobs or possess plumed antennæ (see illustration above).

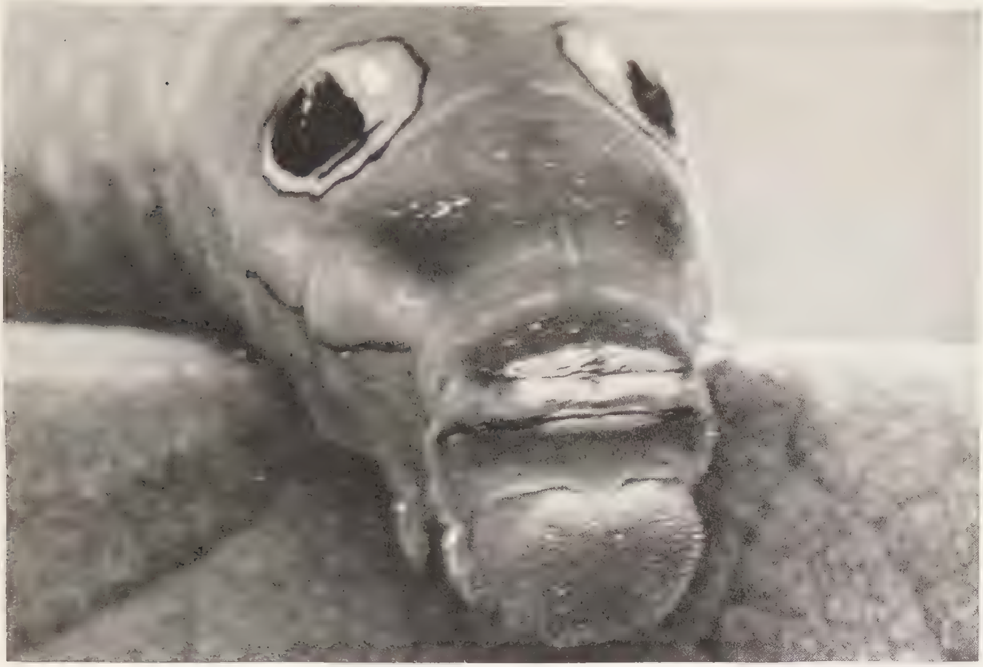
The moths make cocoons of silk, enter the ground, or make cells in wood for their nymphal naps, while the butterflies are satisfied with a sort of hardened integument, or chrysalis, the pupæ being otherwise unprotected.

Most of the butterflies are slender-bodied, while most of the moths are plump.

The butterflies are day flyers, while most of the moths prefer to take wing after the sun has passed below the horizon.

But both moths and butterflies employ marvelously the arts of camouflage to deceive their enemies.

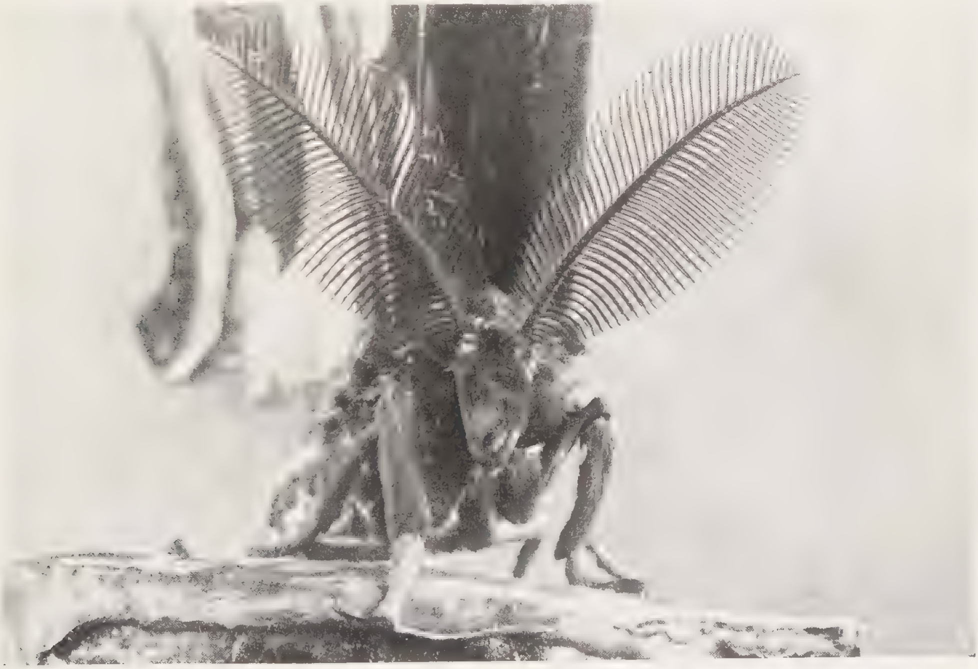
Some of them in the caterpillar stage dress up in stinging hairs that make them unattractive to birds; others possess sharp, acrid flavors that are not pleasing to a bird's palate. Many are ornamented



Photograph by David Fairchild

HOW A CATERPILLAR STRIKES TERROR TO A FOE

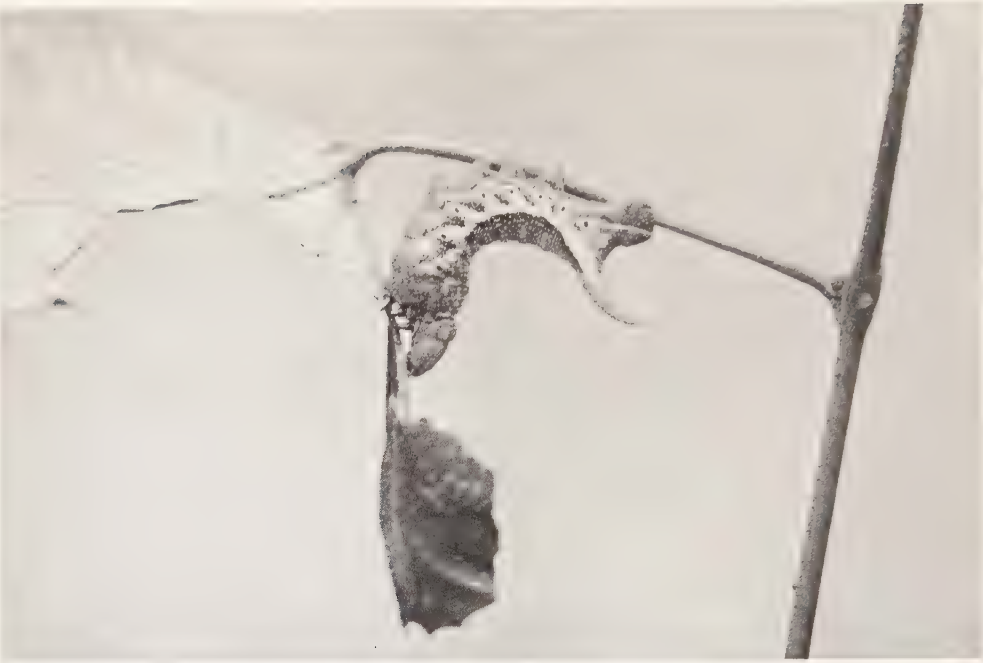
The fearsome mien of this larva of a common Swallow-tail Butterfly (greatly magnified) is only camouflage. The real head of the insect is the small semicircular segment at the bottom of the picture. The huge "eyes" are only make-believe (see text, page 91).



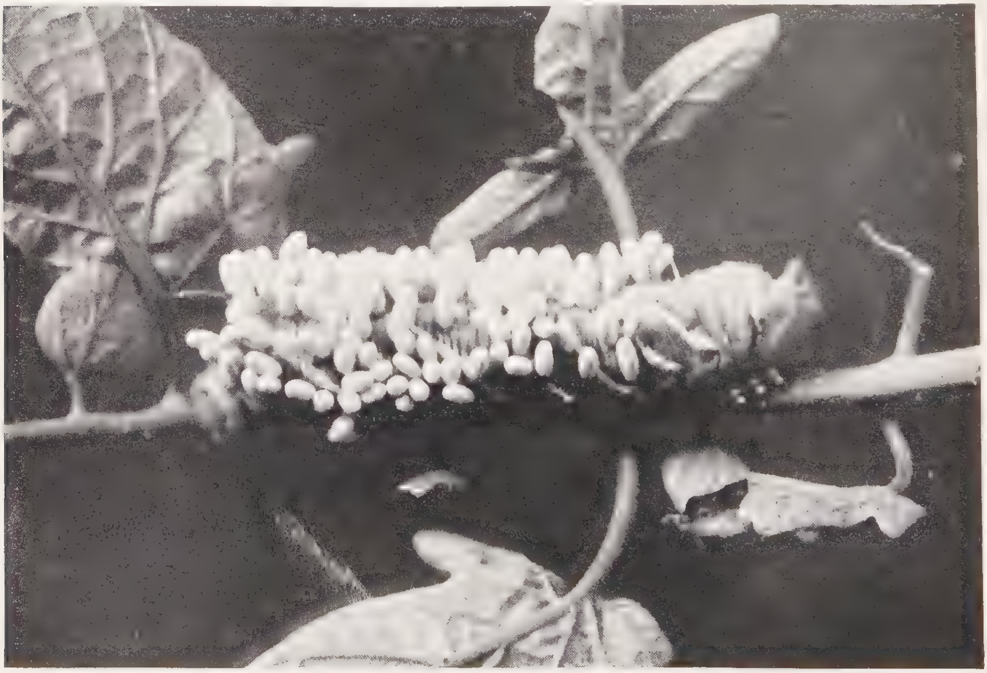
Photograph by Graham Fairchild

A JAVA COUSIN OF "SAMIA CECROPIA"

The antennæ of moths and butterflies are believed to be the aërials through which they receive the calls of their distant mates. The photograph is greatly magnified.



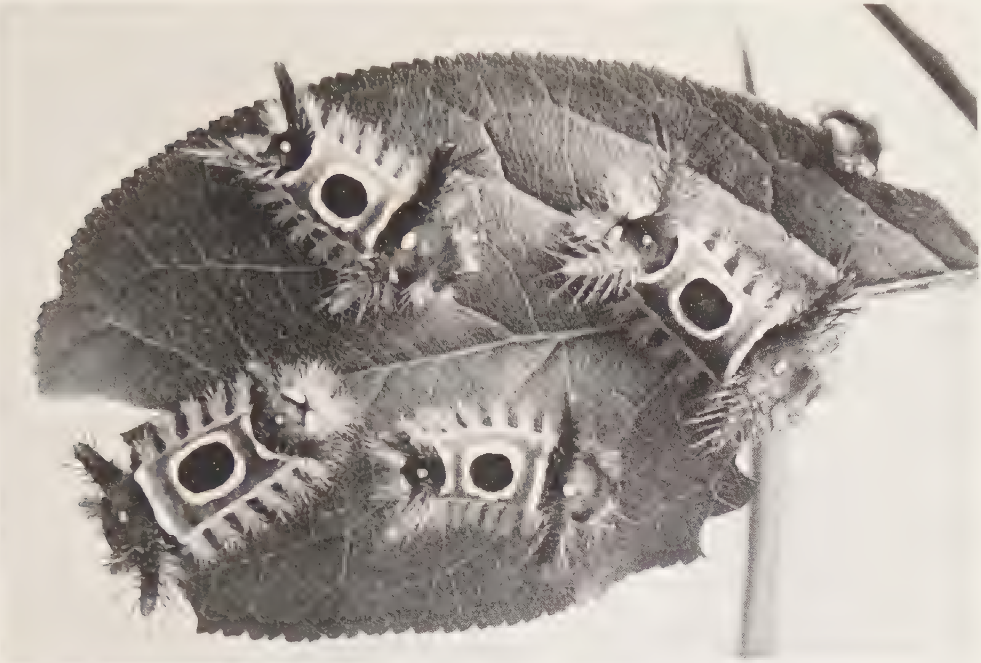
THE CATERPILLAR OF THE HOG SPHINX MOTH (SEE COLOR PLATE XI, FIGURE 8) FEEDING ON THE GRAPE



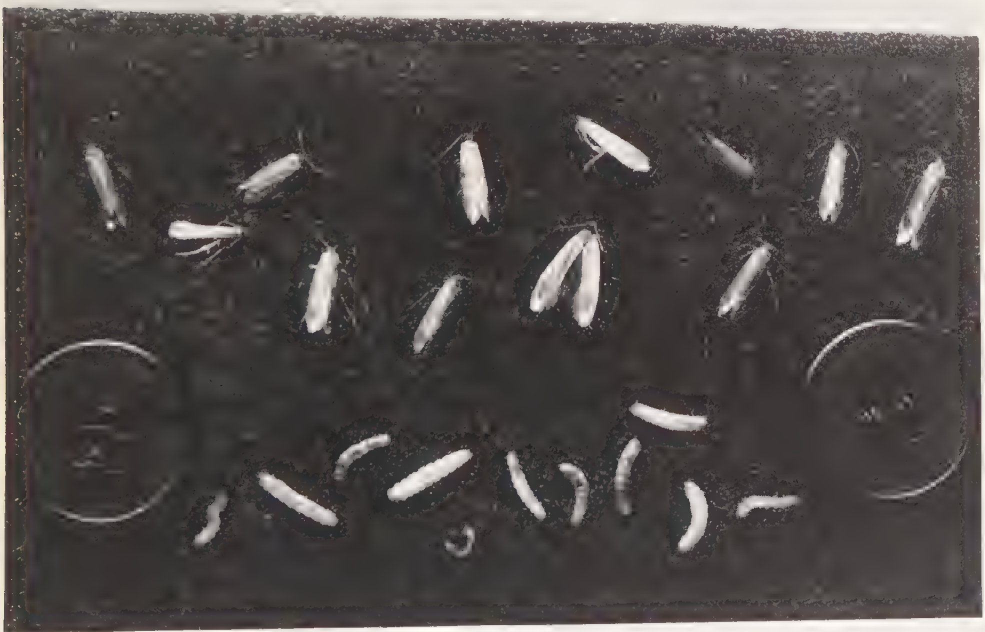
Photographs Courtesy U. S. Department of Agriculture

A TOMATO CATERPILLAR VICTIM OF PARASITISM

One of the fantastic tricks in Nature encountered in the insect world is polyembryony, wherein a single egg of a parasite may produce as many as 300 larvæ of the same sex. The scores of cocoons on this caterpillar's body are the offspring of such a prolific egg (see pp. 91-92).



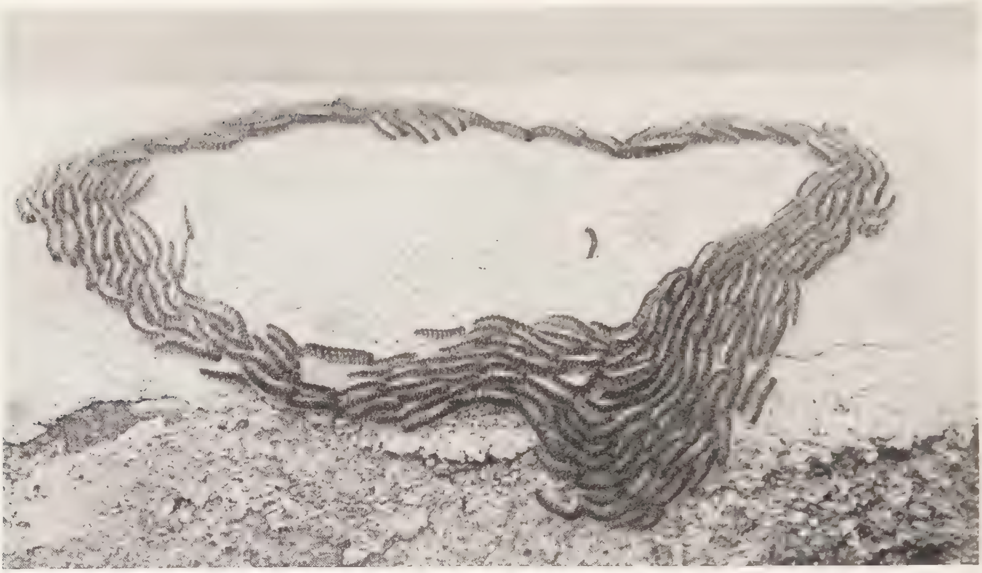
THE SADDLE-BACK CATERPILLAR OF THE SOUTH IS ESPECIALLY FOND OF GREEN CORN BLADES



Photographs Courtesy U. S. Department of Agriculture

READY TO WREAK HAVOC: WEBBING CLOTHES-MOTHS AND THEIR LARVÆ

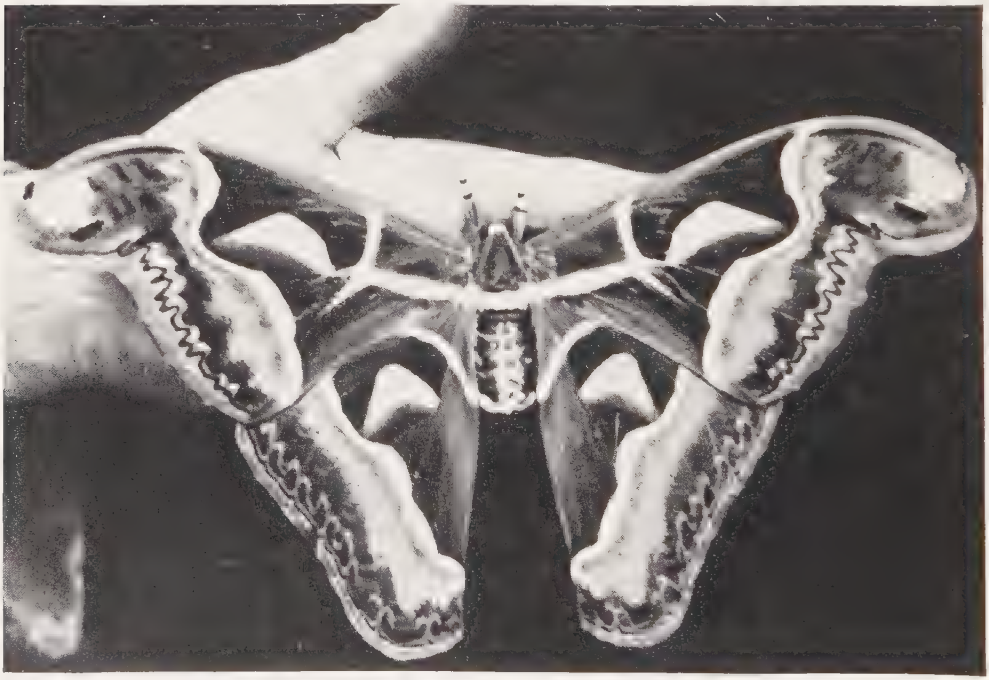
The moth itself is perfectly harmless, but the larvæ that hatch from its eggs spin themselves little transparent tubes or tunnels of silk wherever they go. They feed upon the wool fabric and also use fragments of it in making their pupal cases. These larvæ will riddle this coat.



Photograph from George Whittaker

AROUND, AND AROUND, AND AROUND MARCH THE PINE PROCESSIONARY CATERPILLARS

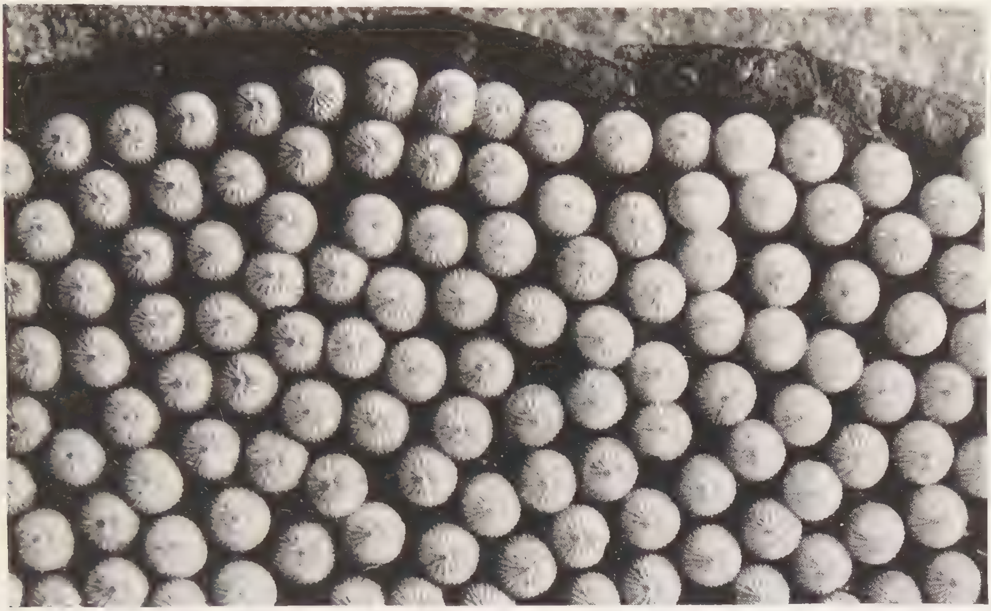
So stupid that they cannot find their way home without their guiding life line, and yet so alert to barometric changes that they make excellent prognosticators of inclement weather, these European cousins of the species that build their tents in our apple trees (see illustration, page 83) are one of the strangest contradictions in the insect world (see text, page 93).



Photograph from Acme

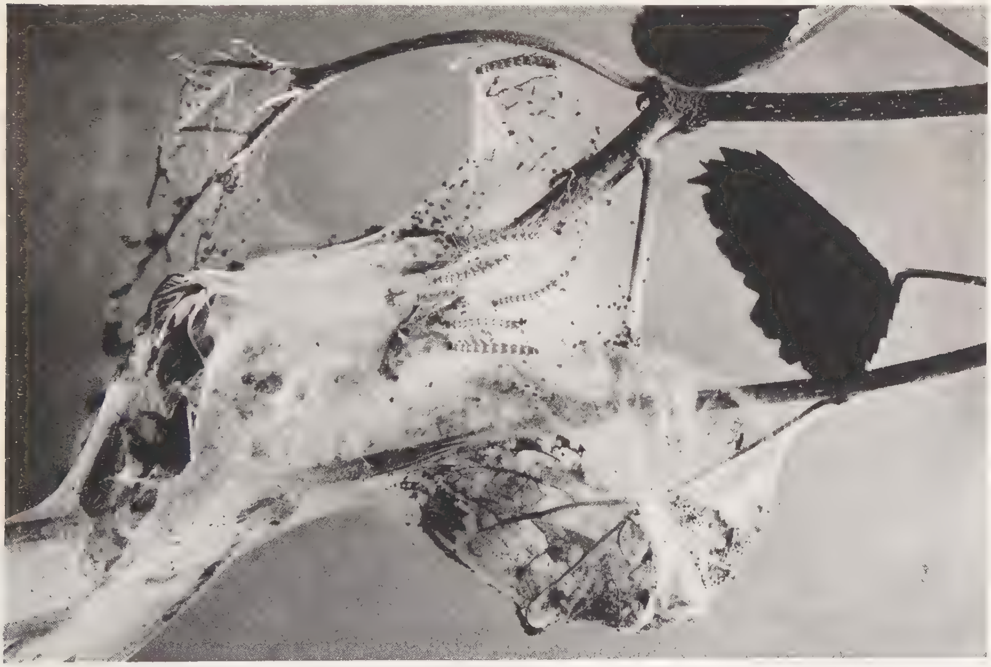
AN ATLAS MOTH FROM THE LONDON ZOÖLOGICAL GARDENS

With a wing-spread of ten inches the Atlas Moth is one of the largest of the Lepidopters. The smallest species of the order have a wing-spread of less than one-eighth of an inch.



BUTTERFLY AND MOTH EGGS ARE OFTEN OF STRIKING DESIGN

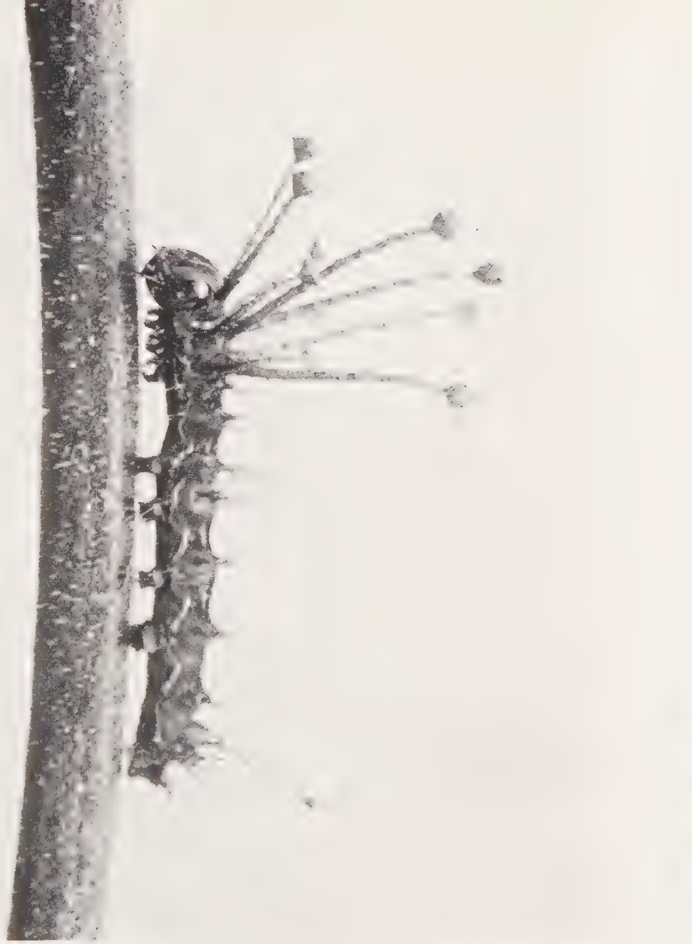
The eggs of butterflies are laid usually upon leaves. In most species the shells are beautiful when examined through a magnifying glass. The extreme summit is always a little rosette of the most exquisite delicacy, and the definite patterns of some eggs are such that we seem to be peering through the circular rose window of a microscopic Gothic cathedral (see text, page 91).

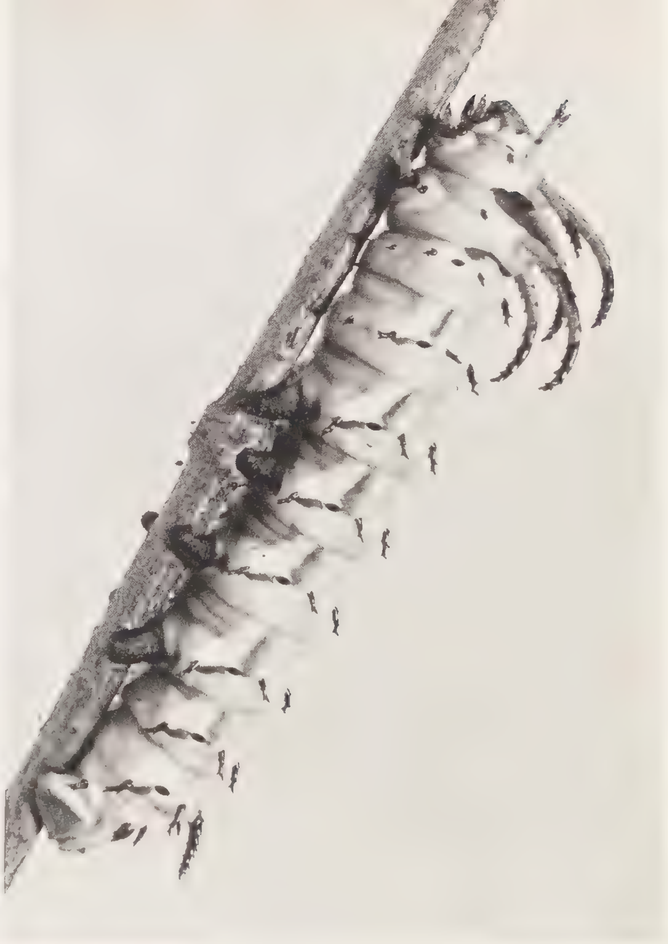


Photographs Courtesy U. S. Department of Agriculture

FALL WEB-WORMS ON A MULBERRY BRANCH

The tent caterpillars are social creatures, building their houses on the community plan. The moth of the Fall Web-worm is shown in figure 17 on Color Plate XIII.





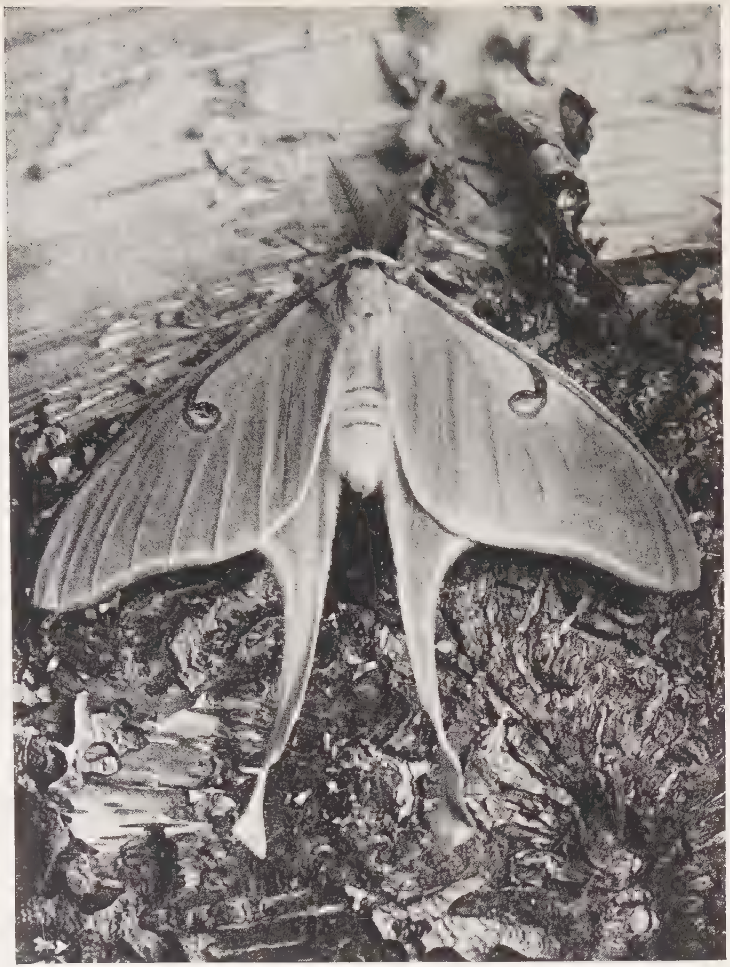
Photographs Courtesy U. S. Department of Agriculture

A CATERPILLAR OF THE ROYAL WALNUT-MOTH IN ITS EARLY YOUTH

Contrast this illustration with that of the Hickory Horn Devil (to the right). Many caterpillars undergo similar remarkable changes on their journey from the egg to the pupal case (see Color Plate I).

THE HICKORY HORN DEVIL, A MATURE CATERPILLAR OF THE ROYAL WALNUT-MOTH

The striking difference between the ugly larva and the beautiful moth is nowhere better illustrated than by contrasting this picture with figure 4 on Color Plate XIV.



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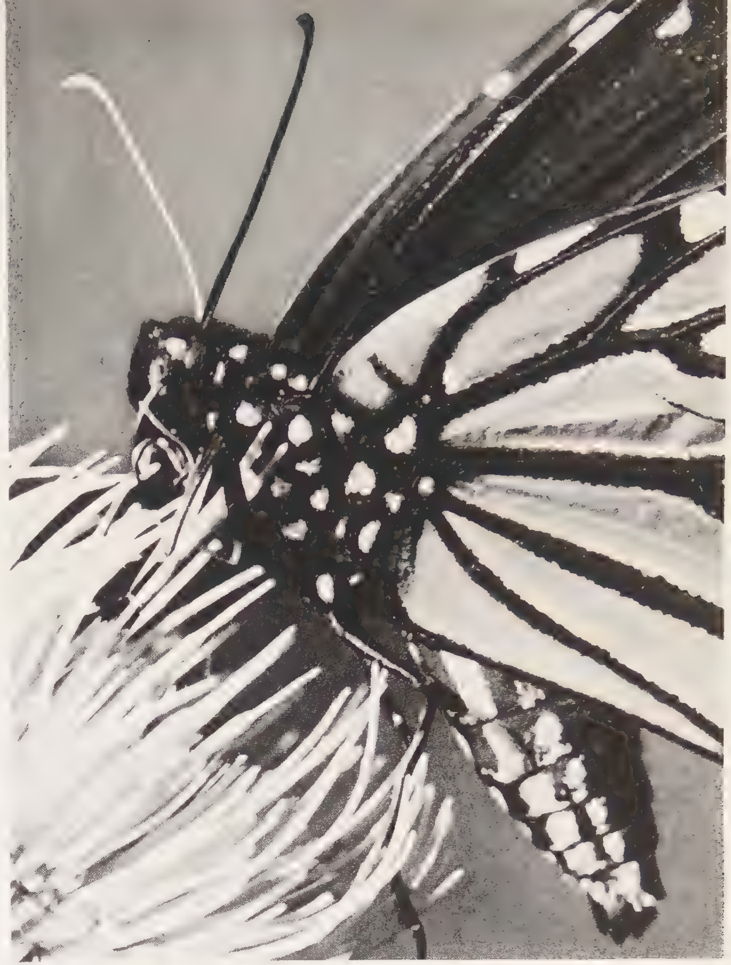
A LUNA MOTH WHILE AT REST (SEE, ALSO, COLOR PLATE XV, FIGURE 4)

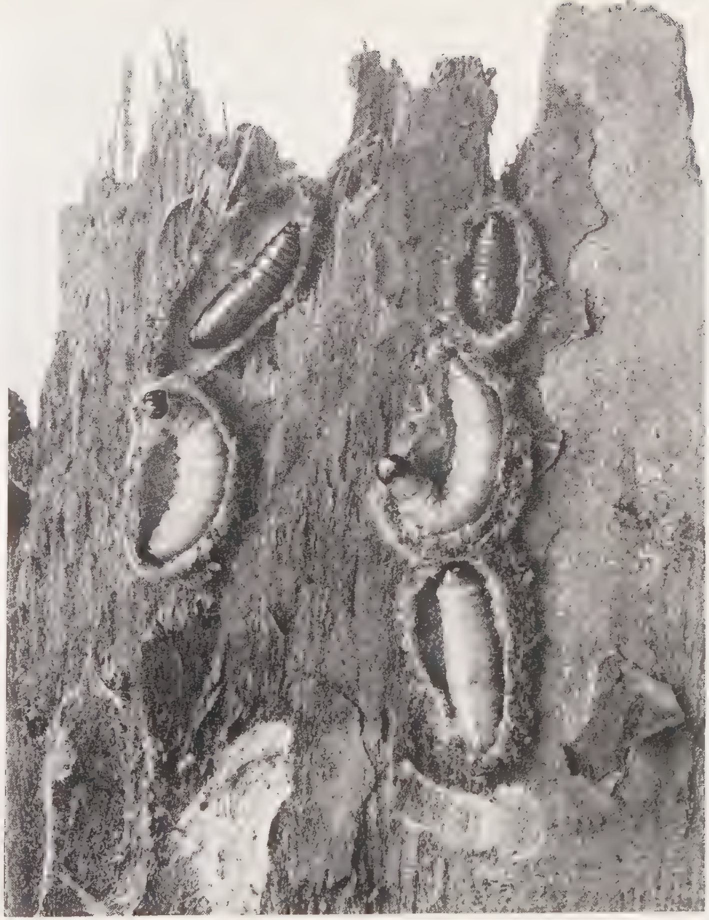
In the Color Plates accompanying this article the butterflies and moths are shown as in flight, but this photograph reveals a Luna Moth alight, with forewings folded over rear wings, blending into its surroundings.



Photograph by Paul Griswold Howes

A MONARCH BUTTERFLY (SEE COLOR PLATE IX, FIGURE 12) SIPPING SWEETS FROM A THISTLE BLOSSOM

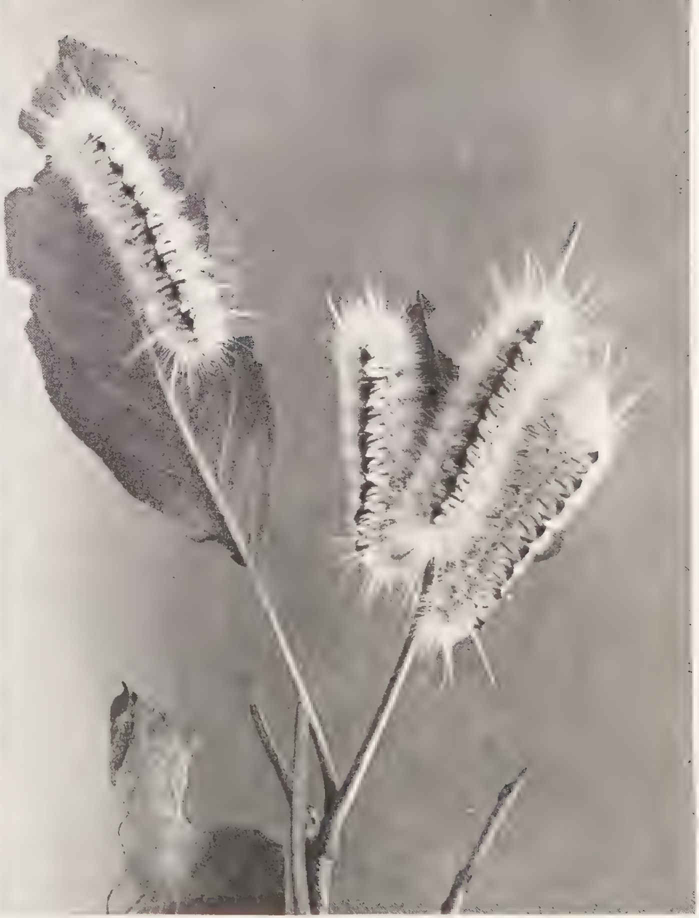
The coiled pumping tongues of butterflies and moths are ideally fitted for draining the nectar cups of the flowers. Moths, being, as a rule, more hairy than butterflies, are better pollen carriers.



Photographs Courtesy U. S Department of Agriculture

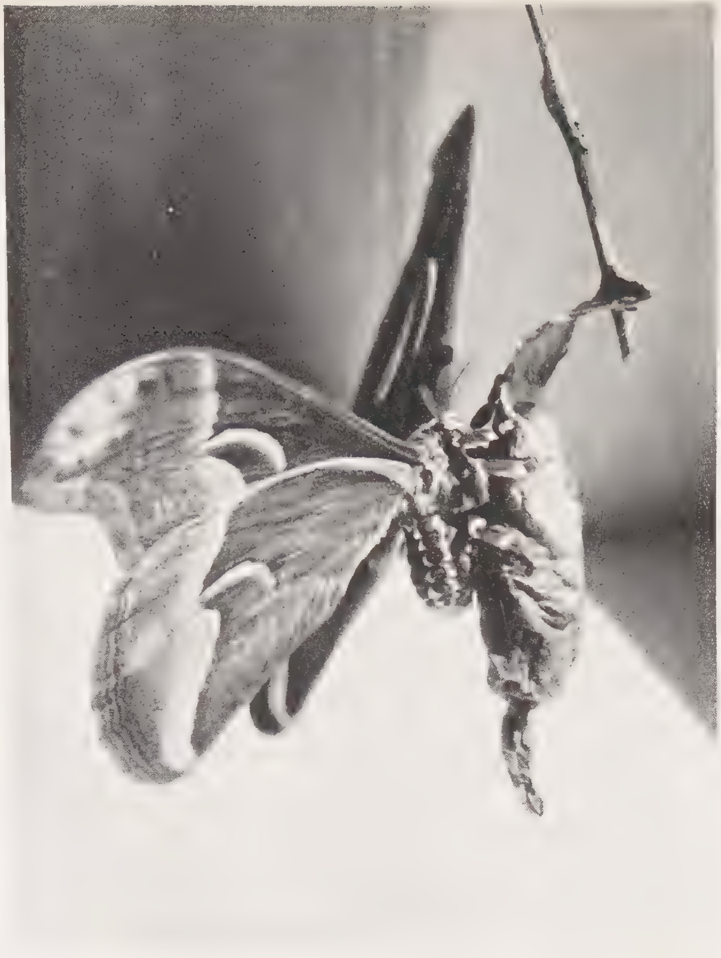
LARVÆ AND PUPA (ENLARGED ONE-HALF) OF THE CODLING-MOTH, WHICH ATTACKS VARIOUS FRUITS

The eggs are laid on the fruit and the larvæ seek a convenient place to enter—usually at the calyx cup, the stem cavity, or an injured spot. After the fruit drops to the ground the larvæ emerge and make their cocoons as shown here.



CATERPILLARS OF THE HICKORY HALISIDOTA ON APPLE TWIGS AND LEAVES

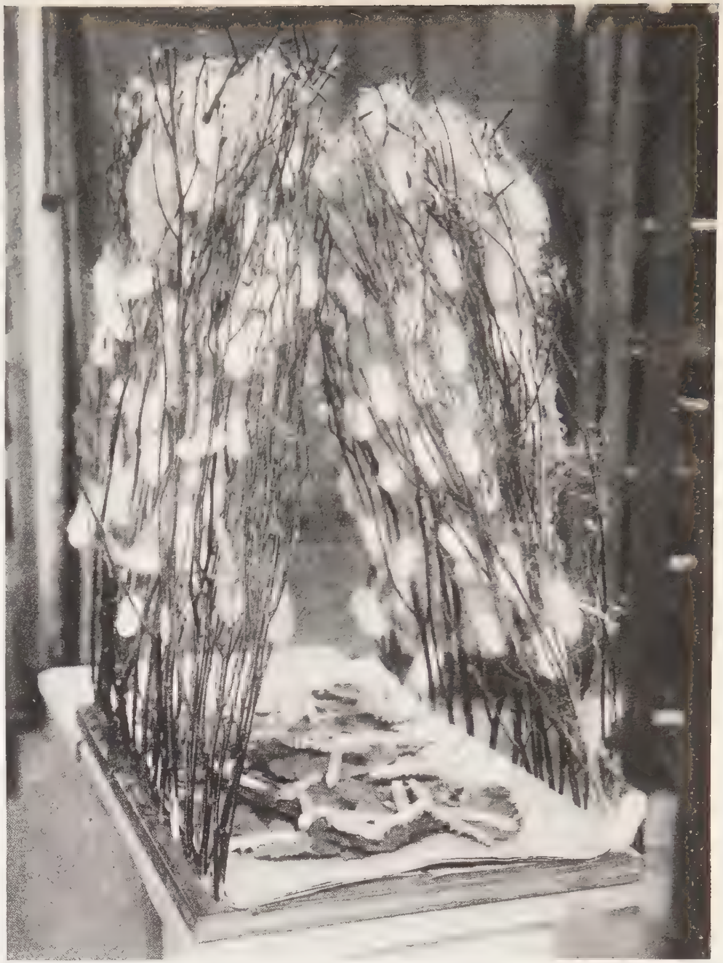
The moth of this caterpillar is a cousin of the ones shown in figures 6 and 7 on Color Plate XIII. The stinging hairs of many caterpillars such as these are an effective means of defense against a large group of enemies.



Photograph by Edwin L. Wisherd

AN AILANTHUS SILK-MOTH LEAVING ITS COCOON

The cocoon of this specimen was found on a tree in the back yard of a downtown Washington residence, and the moth emerged in the offices of the National Geographic Society, where it posed for its picture.



Wide World Photograph

THE BEGINNING OF A SILK DRESS

Some silkworms are feeding on mulberry leaves, others are climbing the brushwood of the spinning hut, and still others are fast asleep in their cocoons (see text, page 97).

to resemble the leaves among which they live, striped to simulate the pine needles on which they feed or the grass on which they dwell, or colored to match the ground on which they crawl, many of them being unbelievably hard to see in their accustomed surroundings.

There are all kinds of moth and butterfly foes—birds that take the adult on the wing or in repose or eat the caterpillars; parasites that attack both the eggs and the caterpillars, and scores of other creatures which consider them fair prey.

Camouflage is often practiced in a peculiar way. For example, our colorful friend, the Viceroy (see Color Plate II, figure 7), copies the Monarch (see Color Plate IX, figure 12) to perfection. Now, the Monarch happens to be a very distasteful creature to a bird because of its acrid blood; but a Viceroy makes a delightful titbit. The bird, because of wider experience with the Monarch, usually lets the similarly colored Viceroy severely alone.

This theory was tested on a monkey, who was given a Monarch to eat; he threw it aside in disgust. Next he was given a Viceroy, and as promptly he cast it aside. Then another Viceroy was offered, this time with the wings pulled off. It was eaten with evident relish.

Many other bird-relished species follow the practice of the Viceroy and imitate acrid varieties, thereby obtaining protection.

GAY COLORS DAZZLE THE PURSUER

Even the gay colorings of our gaudiest butterflies and moths are now thought by leading authorities to be protective, those who hold to this belief asserting that a woodpecker often loses a meal because disappearing brilliancy causes him to lose track of his quarry. As he chases a showy butterfly, his eye is full of the bright color, but when the insect alights it folds its wings above its back and, presto, the bright color disappears! Instead, it shows the drab hue of the underwing, harmonizing with its surroundings.

With the folding of its wings the insect becomes a part of its background and the thwarted woodpecker flies away, doubtless wondering how that bit of bright color escaped his hungry eye. One of the Orange Sulphurs of the Pikes Peak meadows, related to those shown on Color Plate IV, is green underneath. A brilliant flash of color while flying, it seems to vanish when it alights in the grass and closes its wings.

In the Kallima, or Dead-leaf Butterfly, this scheme is strikingly carried out. The underwing surface bears a remarkable resemblance to a leaf. It even has a hindwing projection which looks like the stem of a leaf, and a mark running across the wing appears to be a midrib. Perched on a twig, with closed wings, it perfectly simulates a dead leaf, but with outspread wings it is brilliant bait for a bird (see illustration, page 120).

In the case of the moths, which rest with folded wings instead of upright ones, as do the butterflies (see illustrations, page 85, and Color Plate XV), the brilliant color is on the rear wing, which is covered up by the somber forewing when the insect is at rest.

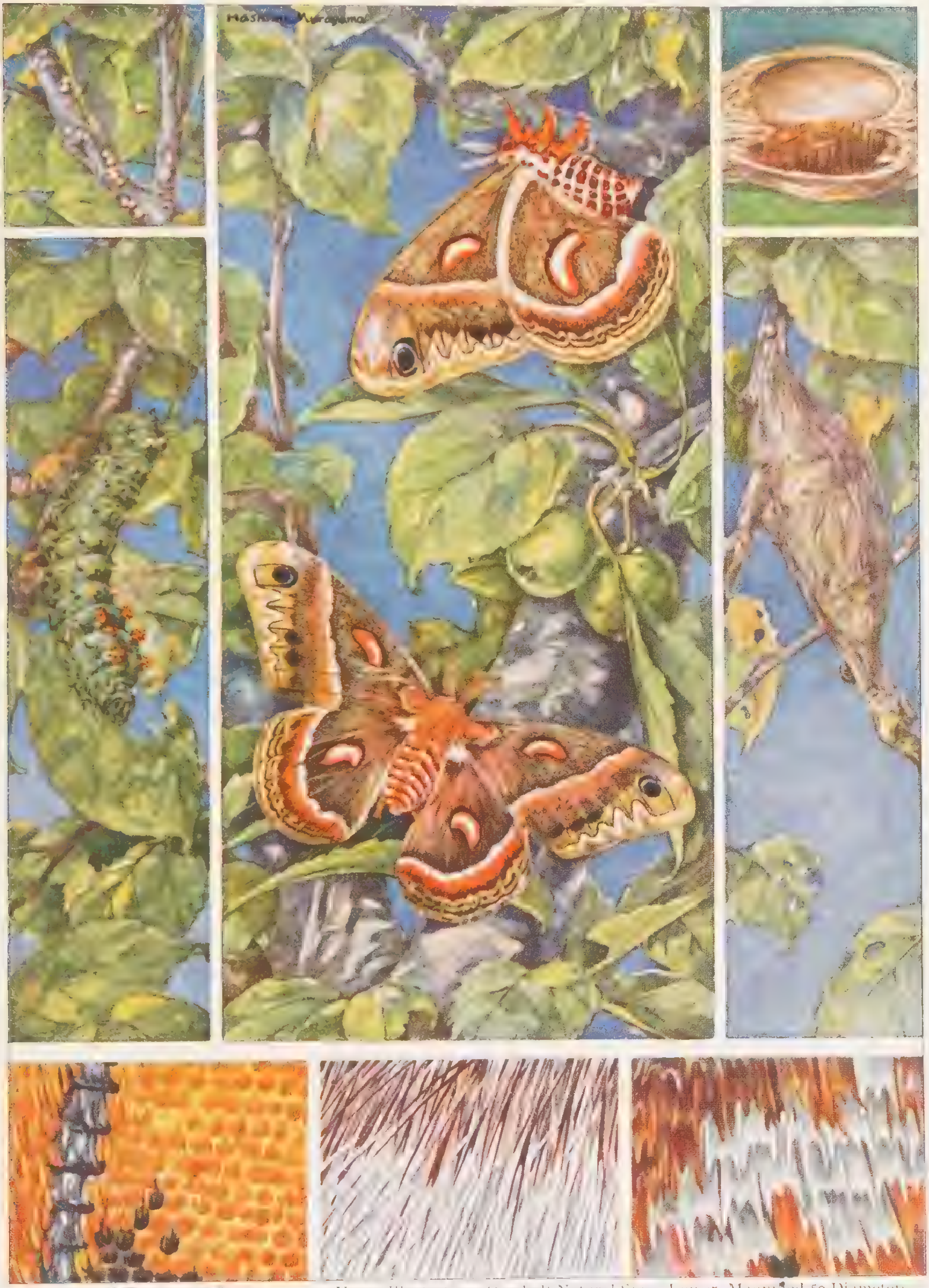
Studies of grasshoppers, locusts, and other winged insects show how this idea of disappearing brilliant colors runs through many families of the entire winged clan.

In collecting moths, one discovers that those which live among the birches usually have a coloration approximating the tones of birch bark, while those which are found usually on the trunks of maple trees show color schemes that make their visibility low. Figures 1 and 2 on Color Plate XII show the contrast between the two species, which are closely related.

But the beelike moths carry the art of camouflage even further than mere passive color protection. If captured or disturbed, they act exactly like the bees they simulate, give off the familiar bee odor, and even pretend to sting, in spite of the fact that they have no stinging apparatus.

MAKING MONSTERS OF THEMSELVES TO WIN PROTECTION

The caterpillars employ many of the arts of camouflage used by the adult butterflies and moths. The measuring-worms, larvæ of the Geometrid moths, simulate in color and general appearance the twigs on which they rest. Disturbed, they stand on their hind legs and look for all the world like small projecting shoots.



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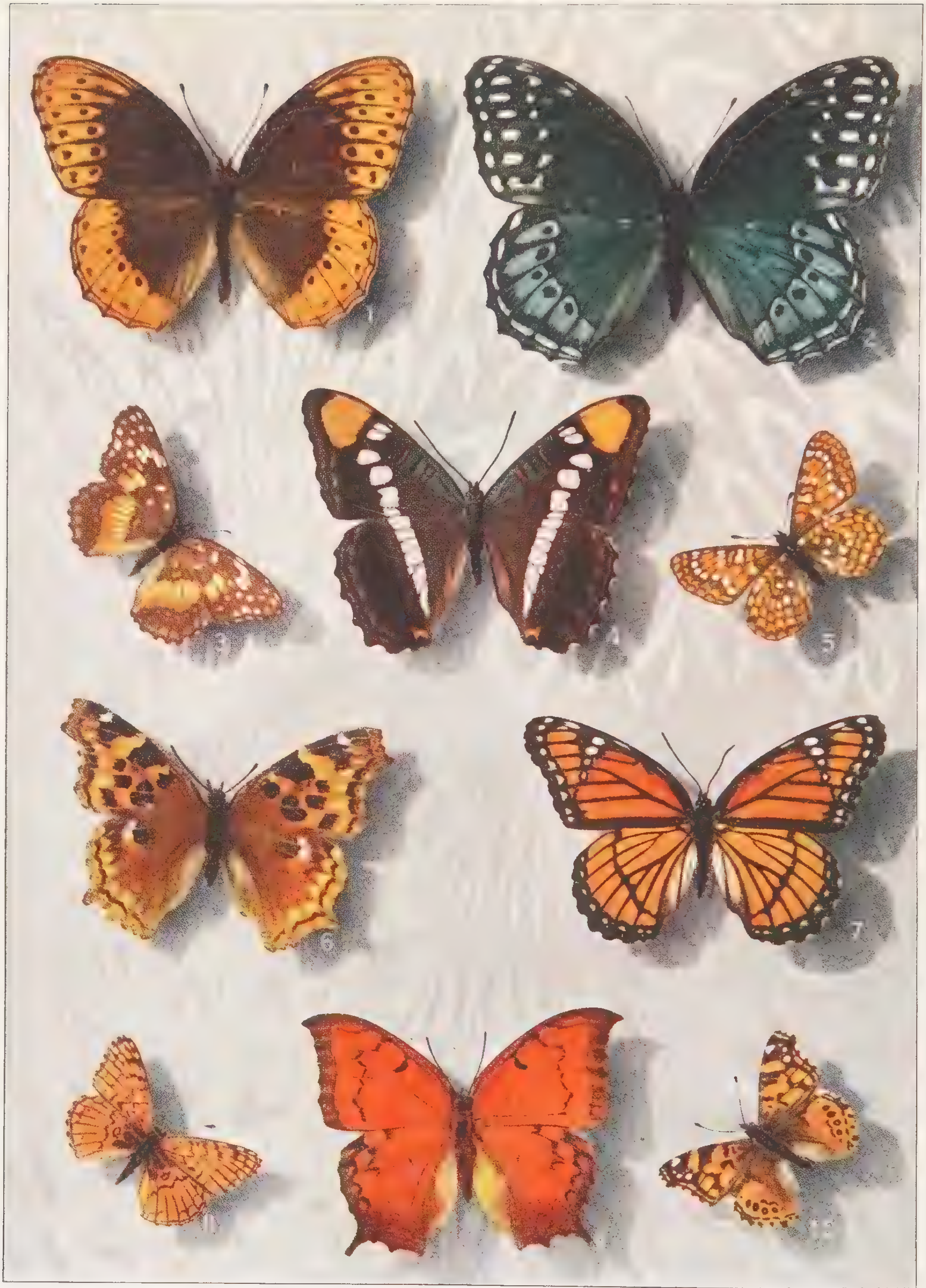
FOUR SUCCESSIVE STAGES IN THE LIFE CYCLE OF A MOTH

Every butterfly and moth must pass through three metamorphic stages before it can become the beautiful winged creature with which we are familiar. Above is the Cecropia Moth, *Samia cecropia* L., a common Eastern species. Its eggs (upper left) are laid in the late spring or early summer. Upon emergence from the egg, the caterpillars are extremely small but soon increase in size, outgrowing their skin, which they shed. After the fourth molt the Cecropia (see panel below the eggs) spins a cocoon of silk (shown cut open at the upper right, and intact, below). From this it eventually emerges as a fullgrown moth.

At the bottom are three drawings showing the appearance, under a microscope, of the familiar "dust" on a butterfly's or moth's wings—actually a series of very fine scales and hairs. The drawing at the left shows the beautiful arrangement of the scales on the Gulf Fritillary Butterfly (see Color Plate III, figure 4); the center shows the forked hairs occurring on the wings of many moths; at the right are the scales of the Cecropia around the eyelike spots on the upper wings.



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Two-thirds Natural Size

THEIR FLIGHTS SPRINKLE AMERICA'S LANDSCAPES WITH COLOR

(1) Diana Fritillary, *Argynnis diana* Cram. [Male]; (2) Diana Fritillary, *Argynnis diana* Cram. [Female]; (3) *Chlosyne lacinia* Gey.; (4) *Heterochroa bredowi* Hbn.; (5) *Euphydryas anicia* Dbldy. & Hew.; (6) Compton Tortoise, *Aglais j-album* Bdv. & Le Con.—also known as *Vanessa j-album;* (7) Viceroy, *Basilarchia archippus* Cram.; (8) *Melitaea neumoegeni* Skin.; (9) Portia Butterfly, *Anaea portia* Fabr.—also known as *Pyrrhanaea portia;* (10) *Vanessa carye* Hbn.

Many species of caterpillars protect themselves from their enemies by assuming a terrifying aspect. For example, the caterpillar of the Tiger Swallow-tail simulates a serpent (see illustration, page 79). The rings of the body just back of the head are swollen, and on top of this protuberance are two large circular marks suggesting eyes. When at rest the creature withdraws its real head and throws up the front part of its body, so that it resembles a snake's head—an impression made doubly effective as it pushes out its curious scent organ, which looks like a forked tongue. Birds have been observed to retreat in alarm as they suddenly came upon one of these menacing-looking, though harmless, creatures.

The Puss Moth, *Cerura*, has a caterpillar with a similar fearsome aspect, and when disturbed it displays a kind of forked tail, within which are concealed long orange-colored extensile threads that can be thrust out and waved viciously. Many other harmless species wear ugly horns, and even intelligent people cannot be induced to touch them.

Most of the Swallow-tail butterflies' caterpillars exude foul odors when disturbed, and Professor Comstock has called them the polecats of the insect world.

Even in the cocoons of some moths and the chrysalis cases of some butterflies, protective devices are employed. The Southern Live-oak Moth has a cocoon that very closely resembles a live-oak terminal bud, especially as both twigs and cocoons are covered with small bits of lichen.

As a decoy to distract the attention of its enemy, the striking Banded Purple butterfly's caterpillar loosely fastens near its feeding place a small ball of leaf scraps closely resembling itself.

PARASITES CONVERT BUTTERFLY EGGS INTO FAMILY NURSERIES

The eggs of butterflies are laid usually upon leaves. In most species the architecture of the shells is beautiful when examined through a magnifying glass. "The extreme summit is always carved by a little rosette of the most exquisite delicacy, often requiring some of the higher powers of the microscope to discern, but arranged in such definite patterns that in looking at them we seem to be peering through the circular rose window of a miniature Gothic cathedral" (see page 83).

The chances of a butterfly's egg producing a live caterpillar are surprisingly small. Ants and spiders regard these eggs as a great delicacy, and a whole group of tiny insects of the fly and bee orders, almost too small to breathe, one would think, insert their eggs into those of the butterflies. Parasites are always on the job to convert the butterfly's egg into a nursery for their own young.

In the case of the Viceroy and its cousins, the female butterfly lays her eggs one at a time and, unless in a hurry to be rid of the task, only one to a bush. She lays them on the tips of the leaves, as a rule. Her eggs are covered with little hairs to protect them.

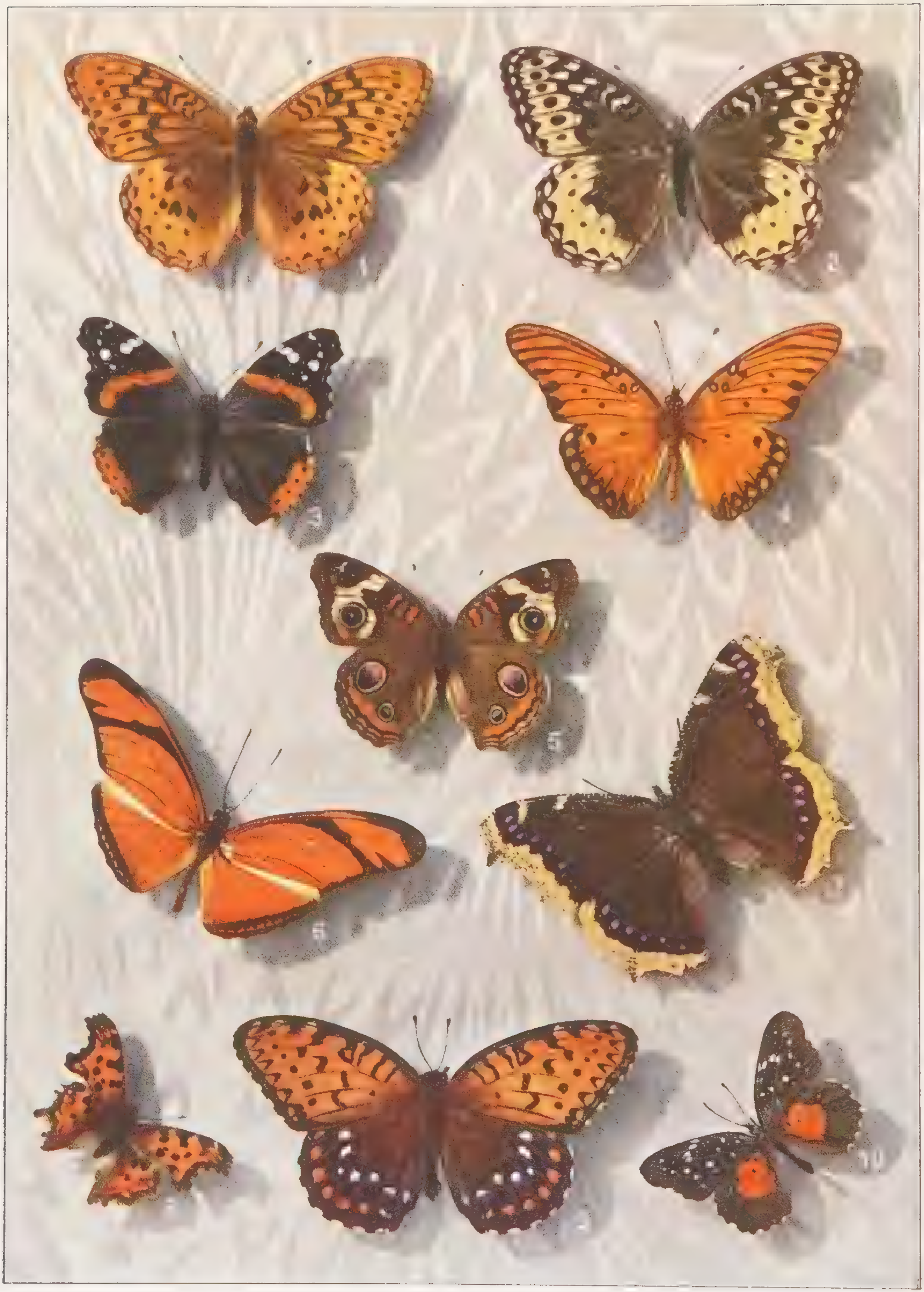
But, with all the effort to conceal her eggs and to safeguard them, Madam Viceroy is not very successful, for a large majority are found to be parasitized.

Some butterflies and moths lay their eggs in rings around twigs and cover them up with a sort of varnish. The Brown-tail Moth covers hers with hairs from her own body, her tail having a bunch of these ready for application to the eggs as soon as laid.

When the caterpillars hatch out, most of them make it their first duty to eat the shells out of which they have just emerged. In the Viceroy the larva then begins to eat the leaf, leaving the midrib.

After having a hearty meal, it retires toward the end of the stripped midrib, digests its meal in the safety of its isolation, and then comes down for another feast. It makes a little packet from bits of midrib and other refuse and uses this as a sort of insect scarecrow, always keeping it at the point on the midrib where the edge of the uneaten portion of the leaf joins it.

Parasites are the bane of the caterpillars as well as of the eggs. All sorts of fly and bee order insects hover around watching for a chance to plant an egg on their bodies. A surprisingly large percentage of them must play unwilling host to the larvæ of these foes. When the parasites' eggs hatch, their little grubs bore into the bodies of their hosts and find a fine food supply in the tissues. A single caterpillar



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Two-thirds Natural Size

THE DAPPER BUCKEYE AND THE STATELY REGAL FRITILLARY ARE FAMILIAR FRIENDS

(1) Leto Fritillary, *Argynnis leto* Behr. [Male]; (2) Leto Fritillary, *Argynnis leto* Behr. [Female]; (3) Red Admiral, *Vanessa atalanta* L.; (4) Gulf Fritillary, *Dione vanillae* L.; (5) Buckeye, *Junonia coenia* Hbn.; (6) Delila, *Colaenis delila* Fabr.; (7) Mourning-cloak, *Aglais antiopa* L.—also known as *Vanessa antiopa;* (8) Wandering Comma, *Polygonia satyrus* Edw.; (9) Regal Fritillary, *Argynnis idalia* Dru.; (10) Crimson-patch, *Synchloe janais* Dru.

may be unwilling host to a dozen parasites, and finally dies about the time the unwelcome guests are ready to pupate. Some parasites lay single eggs, from which as many as 300 larvæ hatch (see illustration, page 80). They are all of one sex, being in reality a single individual subdivided by witchery more subtle than the art of the greatest magician of fairy story. Polyembryony (meaning many individuals from a single egg) is one of the most marvelous of all the recent discoveries in biology.

The caterpillars thrash their heads and tails about when the parasites come around them, and some species, like some of the Sphinx moths, make clicking and squeaking noises.

The gamut which a caterpillar has to run to realize its ambition to reach the winged stage is shown by the researches of Slingerland and Crosby, who found that in some localities 90 per cent of the Tussock Moth caterpillars and chrysalids fell victims to parasites. Twenty different species of flies and hymenopters parasitized those studied.

But often a parasite is "hoist with his own petard," for 14 parasites were found preying on the Tussock Moth's parasites. And then these, in their turn, had parasites attacking them, reminding one of Dean Swift's famous bit of doggerel:

> So naturalists observe a flea
> Hath smaller fleas, that on him prey;
> And these have smaller still to bite 'em,
> And so proceed *ad infinitum.*

THE PSYCHE CATERPILLAR MAKES ITSELF A SUIT OF CLOTHES

Most caterpillars undergo four molts in reaching full growth, though some have been known to pass eight molts. Some change their color pattern after each molt, and most of them, preparing to molt, spin a silk web in which to entangle the legs of the old skin, so that it will remain anchored while they are escaping.

Some caterpillars roll up leaves and make themselves individual shelters. Some species occupy these shelters when not feeding, which therefore last during their full larval life; others feed upon the walls of their abode, building a new shelter when they "eat themselves out of house and home."

But there are others which make themselves suits of clothes.

Whoever has failed to read Fabre's story of the life habits of the Psyche Moth and its caterpillar's coat has missed one of the gems of entomological literature.

Commonly known as the bagworm, the Psyche caterpillar, on emerging from the egg, starts in to build a suit of clothes. Standing on its front legs and holding its tail upright, the naked creature spins a ring of silk, adding bits of wood, leaves, etc., thereto. It continues to spin, adding to the lower edge of the ring until the latter forms a sort of cone.

As the worm grows, it enlarges the bag much after the fashion that hornets enlarge their nests. When the coat gets too heavy, the worm lets it hang down, and henceforth the creature thus encumbered must crawl around on its front legs, encased in a hard, stiff, rough armor.

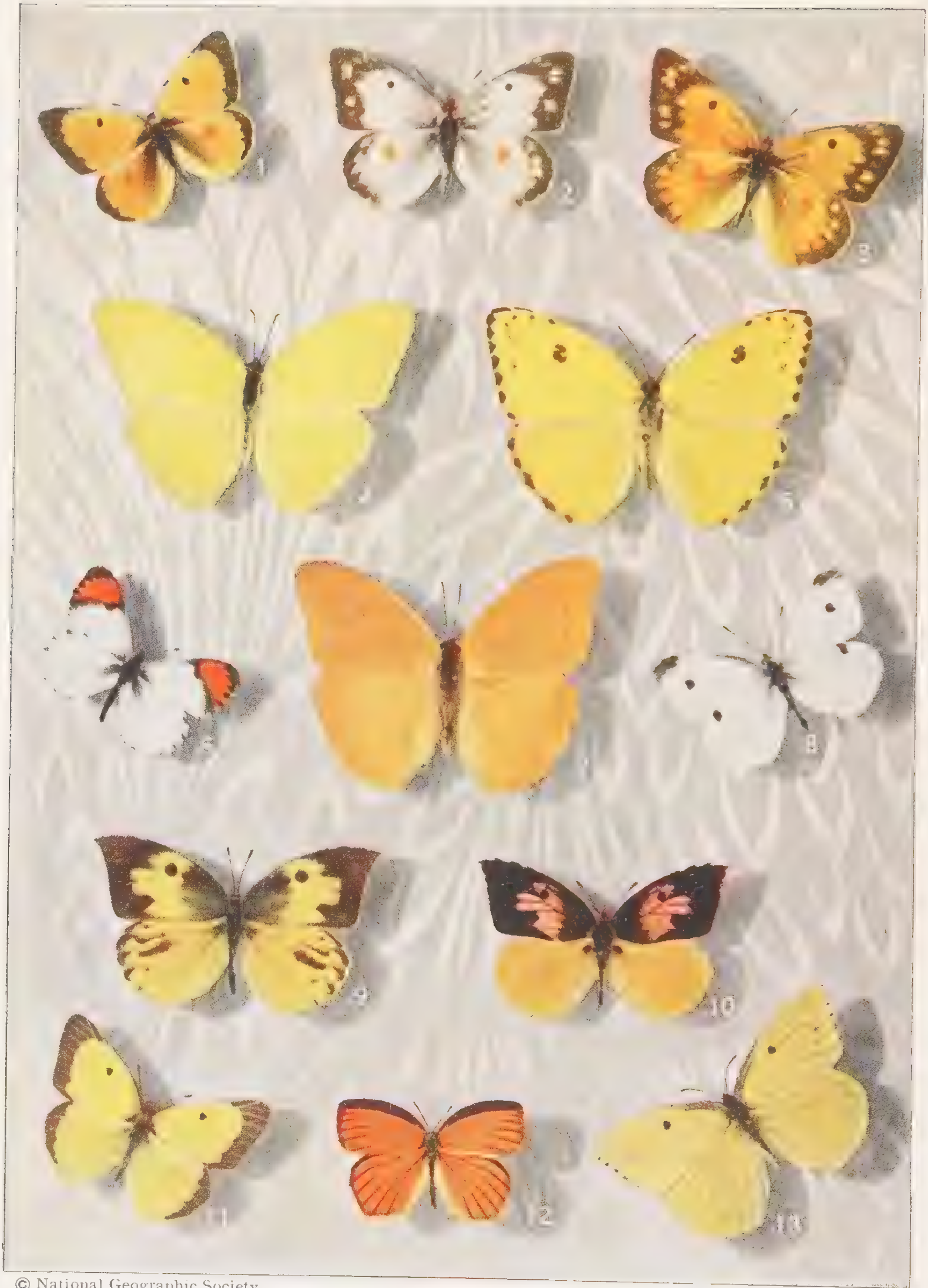
Finally the migratory instinct subsides and the bagworm settles down on the twig of a tree that will constitute the food of its successor. After fastening its wood-embroidered garment to the twig, the insect lines the former with heavy silk, rests awhile, casts its skin, and becomes a chrysalis.

Three weeks later the male chrysalis works himself down to the bottom of his bag, bursts the pupal skin asunder, emerges a full-fledged moth, and as soon as the glue that reinforces his wings is hardened he goes in quest of his mate.

And what a poor creature this mate is. Wingless and footless, she is doomed to die in the home she has built. She creeps down out of her chrysalis skin, welcomes her mate at the door of her house, backs into her chrysalis skin again, fills it partially with eggs, seals it up with what little is left of her body, and dies.

A CATERPILLAR THAT STARS IN THE RÔLE OF WEATHER FORECASTER

Most of us are familiar with the tent caterpillars of spring, summer, and fall. Closely related to our everyday apple tree tent caterpillar is the Pine Processionary of France, which Fabre proved to be at once the prize "bone head" and the blue ribbon weather forecaster of the insect world (see illustration, page 82).



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Two-thirds Natural Size

THE IMMIGRANT CABBAGE BUTTERFLY AND SOME OF ITS YELLOW AND SULPHUR RELATIVES

(1) Orange Sulphur, *Eurymus eurytheme* Bdv. [Male]; (2) Orange Sulphur, *Eurymus eurytheme* Bdv. [Female]; (3) Orange Sulphur, *Eurymus eurytheme* Bdv. [Female]; (4) Cloudless Sulphur, *Catopsilia eubule* L. [Male]; (5) Cloudless Sulphur, *Catopsilia eubule* L. [Female]; (6) Orange-tip, *Anthocharis sara* Bdv.; (7) Large Orange Sulphur, *Catopsilia agarithe* Bdv.; (8) Cabbage Butterfly, *Pieris rapae* L.; (9) Dog's-head Butterfly, *Zerene caesonia* Stoll.—also known as *Meganostoma caesonia*; (10) Zerene Dog's-head Butterfly, *Zerene eurydice* Bdv. [Male]; (11) Clouded Sulphur, *Eurymus philodice* Godt.; (12) *Eurema proterpia* Fabr.; (13) Zerene Dog's-head Butterfly, *Zerene eurydice* Bdv. [Female].

These Processionaries live in tents. The whole tribe marches out, head to tail, single file, in quest of food. Each spins a life line to guide its footsteps back to the nest when its foraging is at an end.

The great French naturalist was able to get a foraging party of Processionary caterpillars on the rim of a huge lawn vase, and then to cut away the life line leading back to the nest. The caterpillars traveled around, came back to the point where the line was cut away, picked up the part they had laid around the vase, and marched around again.

All day long they kept following the line around and around. Night overtook them; they slept, but with the morrow's sun started marching around again.

The second night came, the third, the fourth, and the fifth; the sixth day dawned, and again they resumed the bootless march. For seven days they marched around and around, and were able to find their way back to the nest on the eighth only when one wandering caterpillar, crawling out of the procession in desperation, staked out a highway which the footsore band later decided blindly to follow.

Sight told them nothing, for nine inches away were branches laden with pine needles. Smell gave them no inkling, for almost under their noses was an abundance of their fragrant, favorite diet.

And yet, as a weather forecaster, the Pine Processionary is a marvel. It does not like to be caught out in a storm; so it always stays in its nest when storms are brewing. In its back are protuberances formed of soft, pale, hairless membrane. Of infinite sensitivity, these are supposed to be the antennæ which detect the meteorological waves that tell the caterpillar of approaching bad weather. They appear and disappear at the caterpillars' will—the figurative straws that tell them how the wind blows. And Fabre reports that his caterpillars were better long-range weather forecasters than his government's meteorological station.

ANTS FEAST ON A HONEY WHICH THEY MILK FROM CATERPILLARS

The caterpillars of some butterflies appear to have entered into what human beings would call working agreements with ants. For instance, the caterpillars of the Common Blue or Spring Azure butterfly are attended by ants, who, touching their bodies, get them to exude a sweet fluid from abdominal glands, which the ants drink with relish, just as we milk cows and enjoy the milk. Some of the Hair-streaks (see Color Plate VII)—probably all of them—are attended by ants when in their caterpillar stage. Some of the caterpillars stay in the ants' nests when not out eating.

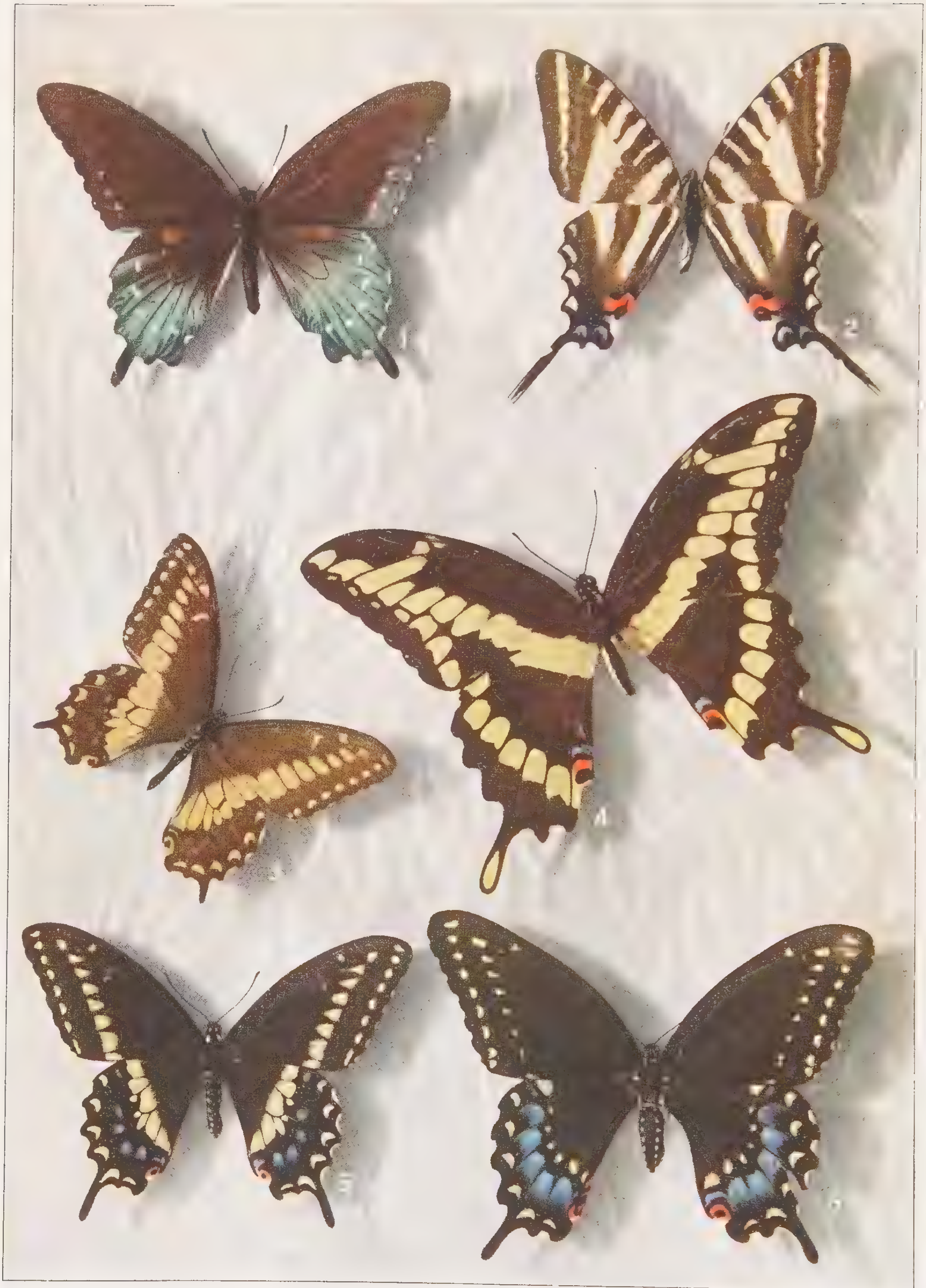
The bee moth and her larvæ live in the hives of bees. When Madame Moth first enters a hive she does it by stealth, in the night, when the bee household is asleep. If she dares to do otherwise, she is stung to death. The hive odor is the countersign to those who would pass the bee's sentries, and the moth which cannot outwit sleeping sentinels is sure to get a reception that is warm, to say the least.

There are scores of burrowing caterpillars which creep up into the stems and down into the roots of briers, small shrubs, vines, and even trees. The straight wood borers, which grub their way through the hardest oak and locust wood and spend three and four years in the heart of the tree, always come to the surface to make a pupating chamber, which has just enough curtain over the window to keep a woodpecker from looking in.

Though spending three or four years as grubs in the tree and having mouths that can masticate hard wood, the emerging moths have neither mouths nor tongues. Their eating has been done for them by their larvæ. They have a very few hours to live—just long enough for a chance to find a mate and die.

MAN HAS DOMESTICATED ONLY TWO INSECTS

Most of the butterflies pupate without spinning cocoons, while many of the moths have cocoons. Some pupate on the ground, some in the grass, some under the ground, some in grain. A thousand plans are followed. Some species of American Saturnids (see Color Plate XVI) spin such excellent cocoons that they would probably be utilized in this country in the production of silk if labor



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Two-thirds Natural Size

THE SWALLOW-TAILS VIE WITH THE FRITILLARIES FOR HONORS IN THE BEAUTY CONTEST OF THE BUTTERFLY WORLD

(1) Blue Swallow-tail, *Papilio philenor* L.; (2) Zebra Swallow-tail, *Papilio marcellus* Cram.—also known as *Iphidicles ajax marcellus*; (3) Black Swallow-tail, *Papilio polyxenes* Fabr. form *americus* Koll.; (4) Giant Swallow-tail, *Papilio cresphontes* Cram.; (5) Black Swallow-tail, *Papilio polyxenes* Fabr. form *asterius* Cram. [Male]; (6) Black Swallow-tail, *Papilio polyxenes* Fabr. form *asterius* Cram. [Female].

were as cheap and living as hard as in China and Japan.

The silkworm, whose cocoon China taught the world the art of using in the fashioning of the world's finest textiles, shares with the honeybee the distinction of being the only domesticated insects in the world.

The statistics of sericulture show that the world production of the silkworm's thread amounts, exclusive of the undetermined quantity produced and used in the interior of China, to nearly 90,000,000 pounds a year.

As there are more than 900 miles of silk fiber in each pound, one may gain some conception of the enormous industry of these larvæ of the silkworm moth, *Bombyx mori*, and related species, the latter producing only a small share of the total.

40,000 SILKWORM EGGS TO THE OUNCE

The eggs are laid once a year, in the summer, and are so small that 40,000 of them weigh only an ounce. They hatch the following spring. In about six weeks and after four molts the caterpillars are full grown and are about three inches long. They then are ready to pupate.

After a restless search the silkworm finds a small twig, produces from the spinneret, a tiny orifice in the lower lip, a bit of sticky, viscid fibroin, which quickly dries and adheres to the twig. By a series of waving motions with its head and a circular motion with its body, it draws out the fibroin in the shape of a minute double thread, slightly twisted, and with it a silk gum that cements the two threads together (see page 87).

The worm seldom stops until its cocoon is complete, and produces from 500 to 1,300 yards of silk thread for the task. Those cocoons that are wanted for silk are usually subjected to heat and the insects killed; but where particularly brilliant silks are desired, the fiber is reeled from the cocoon while the worm is still alive.

Those cocoons selected for "seed" are kept, and in from 20 to 40 days the moth emerges—a poor, bedraggled creature, with mouth incapable of eating anything and with wings too weak for flight. After mating, the female lays her eggs and dies—a melancholy victim of centuries of domestication and specialization in silk production.

Transcontinental silk trains, moving without schedule and having the right of way over even the crack limited expresses, rush from Vancouver to New York with the product of billions of these little laborers of the Orient that produce the raw material for the sheerest of hose and the heaviest of brocades.

THE SILKWORM'S RIGHT TO A NICHE IN THE HALL OF FAME

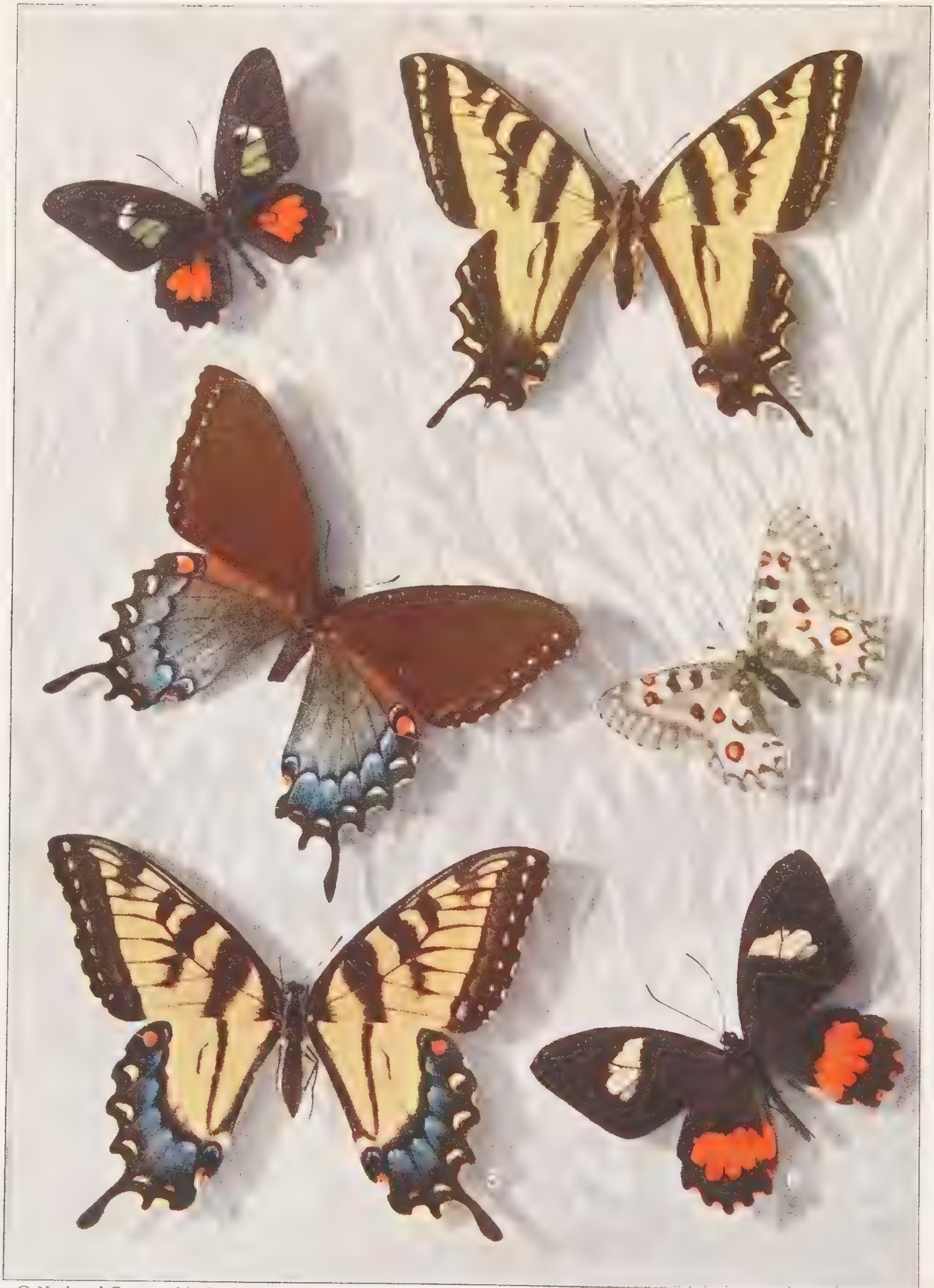
The silkworm deserves a niche in the Hall of Fame for another reason besides its gift of the world's most prized textile: it was the story that the sick silkworms of France told the great Pasteur which led him from his beloved crystals into the study of contagious disease and the science of bacteriology, with a resultant marvelous saving of human life.

Chrysalids range from the beautiful to the ugly. The Milkweed Butterfly has a charming green house with golden nails; the Violet-tip possesses one colored like dead leaves, marked with a Roman nose, and studded with silver or gold spots.

During its nymphal slumber great changes take place in the chrysalis. Practically the entire structure of the caterpillar is torn down. Its organs, its muscles, its entire being, except a few nerve centers, are thrown into the caldron of change and reduced to a sort of milky chyle.

But certain buds, which may be detected in the caterpillar at the beginning of the pupating process, begin to take form, becoming wings, tongues, compound eyes, etc.

In due course, sometimes in a few weeks, at others after the passing of a winter, the inert mass concealed within and cemented to the outer integument of the pupal cast awakens to life, and there emerges, in the words of Scudder, "like well-clad Minerva from the head of Jove, a creature of no apparent kinship either with the case that enwrapped it or the lowly worm that preceded it; a creature with a soft, elastic body, buoyant as the air in which it floats, with spreading feelers and broad spanned wings, clothed with jeweled dust and silken hair, which



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Two-thirds Natural Size

THE TIGER SWALLOW-TAIL (2) HAS MATES OF TWO DISTINCT COLORS (3 AND 5)

(1) *Papilio mylotes* Bates. [Male]; (2) Tiger Swallow-tail, *Papilio glaucus* L. [Male]; (3) Tiger Swallow-tail, *Papilio glaucus* L. form *glaucus* [Female]; (4) Parnassian Butterfly, *Parnassius smintheus* Dbldy. & Hew. [Female]; (5) Tiger Swallow-tail, *Papilio glaucus* L. form *turnus* [Female]; (6) *Papilio mylotes* Bates. [Female].

reflect the colors of the rainbow and in their delicate combinations defy the painter's palette."

THE BIRTH OF A BUTTERFLY

Creeping out of its pupal case, the butterfly rests with its back downward and its wings limp. With a violent pumping of its abdomen, it forces a liquid glue out through the hollow veins of the wings, between the upper and lower membranes, and even into the scales themselves. When this glue hardens, the veins become solid struts instead of hollow tubes, the upper and lower membranes become permanently bound together, the scales assume color and shape, and the insect becomes a new-blown, full-grown butterfly, ready to fly away into the romance of adult existence.

The scales that arrange themselves in such marvelous patterns on the wings of moths and butterflies are modified hairs. Under the microscope one sees every gradation from a thoroughly orthodox, elongated hair to the broad, corrugated, serrated scale. As will be noted in the microscopic section at the bottom of Color Plate I and the drawing, page 78, one may see the whole series on the wings of a moth and butterfly.

The tongues of butterflies and moths are marvelous adaptations to their needs as nectar sippers. Some, as in the case of several of the Sphinx moths, may be as much as six inches long, two or three times the length of the insects' bodies (see Color Plate X, figure 7). When not in use, they coil up like the hairsprings of watches and are concealed under little hairy tippets projecting on either side of the coil.

The tongue consists of two sections, so joined together that the groove on the inner side of each forms one-half of the hollow tube they jointly make. Through this the insect draws the nectar out of the flower much as we draw ink out of a bottle with a fountain-pen dropper.

SOME MOTHS AND BUTTERFLIES NEVER EAT

In many cases these tongues are so long that in the pupal cases special coverings are provided for them. The natives of the South, noting the similarity of these tongue cases to wind instruments, call the pupæ bearing them "horn-blowers."

The mouth parts of the scaly-wing order range from this high specialization on down to the simple biting kind, such as are possessed by locusts and beetles.

In some of the butterflies and moths, like the silkworm moth, the period of adult existence is so short that they never eat. Consequently, their mouth parts have completely atrophied and starvation would be their inevitable fate if early death in other forms did not sooner supervene.

It is an interesting fact that, with but rare exceptions, the lowest forms of scaly-wing life fly by night, the middle forms by twilight, and the highest forms by day. It is likewise to be noted that, with only a few exceptions, the lowest forms are the most nearly colorless, and the highest forms the most colorful.

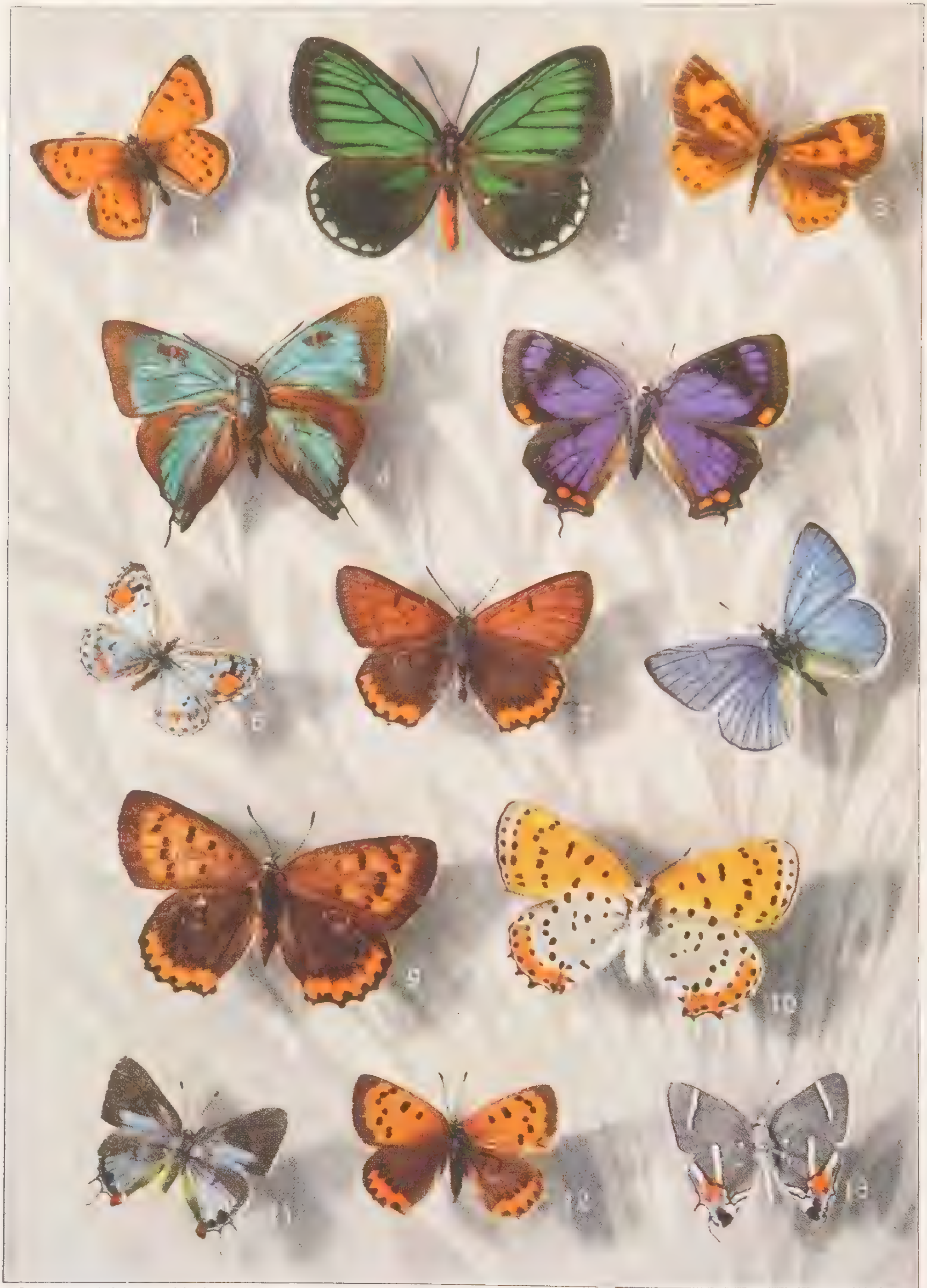
BUTTERFLY BROTHERS AND SISTERS DIFFER RADICALLY

Some butterflies have a single generation a year, others produce two broods, and still others three broods. In some cases the different broods are so different that they long were thought to be of different species. For instance, the familiar Cabbage Butterfly (see Color Plate IV, figure 8) is smaller and of a duller white in the spring brood than in later ones, and possesses broader black markings on the tip and middle of the wings.

In the American Copper spring individuals are of a more fiery red and have broader orange bands on the surface of the hind wings than later broods. Likewise, the Pearl Crescent of spring is so different from that of midsummer that the two broods passed for different species until the observant Edwards proved the contrary.

The second type of dimorphism is illustrated in the Violet-tip, where there are two forms arising from the same brood, differing alike in the brightness and variegation of their colors and in the form of the wing itself. The Blue-eyed Grayling is another which has two forms that were long able to masquerade as different species.

Then there comes a third type of dimorphism that is a mixture of both. The



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Natural Size

A FEW OF THE COPPERS AND THEIR KIN

(1) *Heodes cupreus* Edw.; (2) Atala, *Eumaeus atala* Poey; (3) Wanderer, *Feniseca tarquinius* Fabr.; (4) Great Purple Hair-streak, *Atlides halesus* Hbn.—also known as *Thecla halesus*; (5) *Hypaurotis crysalus* Edw.; (6) *Philotes sonorensis* Feld.; (7) Bronze Copper, *Heodes thoe* Bdv. [Male]—also known as *Chrysophanus thoe;* (8) *Glaucopsyche lygdamus* Dbldy.; (9) Bronze Copper, *Heodes thoe* Bdv. [Female]—see No. 7; (10) Bronze Copper, *Heodes thoe* Bdv. [Underside]—see No. 7; (11) *Strymon martialis* H. S.; (12) American Copper, *Heodes hypophlaeas* Bdv.; (13) *Strymon acis* Dru. [Underside].

Zebra Swallow-tail (see Color Plate V, figure 2) is an example of this type. It appears in three forms—*Papilio marcellus*, the *Iphidicles ajax marcellus* of the field books, emerging in early spring, with tails three-fourths of an inch long and tipped with white; *Iphidicles ajax telamonides*, appearing in late spring, with tails a little longer and bordered with white on either side for half the length or more; and the simple *Iphidicles ajax*. *Marcellus* and *telamonides* come from a single brood, *marcellus* hatching earlier. *Ajax* comes from the eggs of *marcellus* and *telamonides* alike. Its eggs in turn produce *marcellus* and *telamonides* in the spring.

In the case of the Pearl Crescent, which has both spring and summer forms, the summer form may be made to take the coloring of the spring form simply by chilling the chrysalis, which indicates the rôle played by winter in producing the spring form.

SPRING AZURE HAS MANY COLOR VARIATIONS

The Spring Azure is an example of a widely distributed species which takes on color variations, from its southernmost to its most northerly range, some broods in the South approximating the Northern forms and others widely varying.

Finally, there is sexual color variation. In the Tiger Swallow-tail one type of female is colored like the male; another type is black (see Color Plate VI, figures 2, 3, and 5); but not a black female can be found in the northern range of this species.

The Dusky Skipper, likewise, has a normally colored female and a black one, and Scudder played a joke on the male of this twin-wife species by christening him the Mormon.

Some species have white or albinic females in addition to the orthodox ones, such as the Clouded Sulphur. And still other species show all the males with one color scheme and all the females with another. The Goatweed Emperor, the Spring Beauty, the Diana Fritillary (see Color Plate II), and the Black Swallowtail are all examples of this type of color variation.

Both butterflies and moths survive the winter in the egg, as caterpillars, as pupæ, and as adults. Some species pass it in egg form, these eggs usually being covered with a varnish to protect them. Most Swallow-tails pass it as chrysalids, most Angle-wings as adults.

About half the species hibernate as caterpillars, varying from the newly hatched Fritillaries and Graylings, whose only food has been the shells from which they emerged, to the full-grown caterpillars, which pupate in the spring without a mouthful to break their long fast.

Many of the caterpillars construct for themselves highly deceptive and thoroughly ingenious little retreats in which to rest when not eating or in which to spend the winter. For instance, the beautiful Banded Purple inhabits birch trees. Its caterpillar takes a small shoot on a budding birch, makes a shelter from it, and ensconces itself therein. Ichneumon flies buzz about, exploring the tree in search of caterpillars which they can convert into animated larders for their own young.

But the Banded Purple's caterpillar does not need to worry a great deal, for its snug little nest looks so like the birch bud that the flies usually fail to penetrate the camouflage.

THE AVERAGE BUTTERFLY'S SPAN OF LIFE IS FOUR OR FIVE WEEKS

How long do butterflies and moths live? is a question often asked. In those species which have atrophied or rudimentary mouth parts it may be assumed that their span of life is necessarily brief. Others live many weeks, and some, it is believed, as much as ten months; but the average life is believed by Scudder to be around four or five weeks.

Some species live long enough even to "follow the swallow" in pursuit of spring. The autumn brood of the Monarch (see Color Plate IX, figure 12), for instance, gather in hordes in the northeastern States, and, their numbers swelling by recruits as they fly onward, finally reach the far south, to winter in lands of sunshine.

Dr. Frank Lutz says that great clouds of Painted Lady butterflies have been seen to land on the Bermuda Islands from the northwest, having covered 600 miles of ocean.

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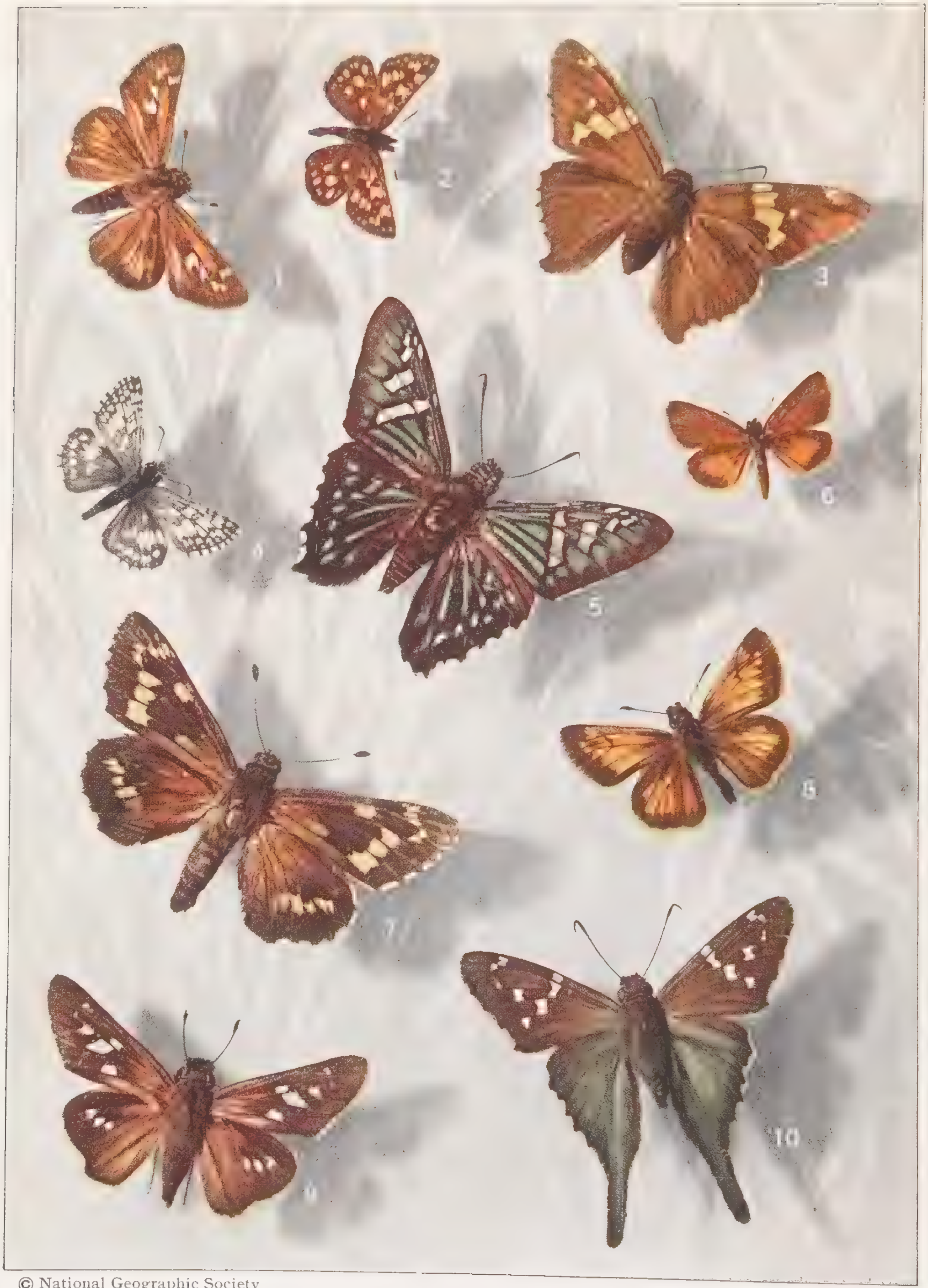

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Natural Size

BEAUTY PRIZE-WINNERS OF THE SKIPPER TRIBE, SO CALLED FROM A PECULIARITY IN FLIGHT

(1) *Atalopedes campestris* Bdv.; (2) Arctic Skipper, *Carterocephalus palaemon* Pall.—also known as *Pamphila palaemon* and *Pamphila mandan*; (3) Silver-spotted Skipper, *Epargyreus tityrus* Fabr.; (4) Tessellated Skipper, *Pyrgus tessellata* Scud.—also known as *Hesperia tessellata* and *Hesperia montivaga*; (5) *Eurycides urania* W. & H., (6) Least Skipper, *Ancyloxypha numitor* Fabr.; (7) *Megathymus neumoegeni* Edw.; (8) Hobomok Skipper, *Poanes hobomok* Harris—also known as *Atrytone zabulon*; (9) Brazilian Skipper, *Calpodes ethlius* Cram.; (10) Long-tailed Skipper, *Goniurus proteus* L.—also known as *Eudamus proteus*.

The Mourning-cloak (see Color Plate III, figure 7) and some of the Tortoise-shells have also been observed as immigrants at times.

There are a thousand and one wonder stories that might be written about butterflies and moths. That master of butterfly habits, the late S. H. Scudder, wrote a whole volume about the Milkweed Butterflies alone, and yet he admitted that much had been left untold. Perhaps each of the 9,500 species of the scaly-winged order could instruct us as interestingly and to as great length as the Monarchs.

If we should journey to the top of Mount Washington, New Hampshire, we might find a dainty little Fritillary, *Brenthis montinus*, or that other cheery little satyr, *Oeneis semidea* (see Color Plate IX, figure 2), imprisoned on the heights because the weather is too warm below. Both came down out of the Arctic on the crest of the great Ice Age, and when the ice finally receded they were left, Robinson Crusoe fashion, on an island of cold in a sea of warm air.

O. semidea occupies only that section of the mountain above 5,000 feet. It is also found on some of the high peaks of Colorado, whence it came out of the Arctic under conditions similar to those which brought it to Mount Washington. *B. montinus* lives below the forest line in the White Mountains, as *O. semidea* lives above; but it, too, is segregated on an island of cold. These frail little creatures demand for their existence weather so harsh and stormy that even man finds it hard to face.

BUTTERFLIES HAVE PSYCHOLOGICAL PECULIARITIES

Or we might turn aside and note with Scudder the psychological peculiarities of butterflies (he tells us that when he first prepared to write an essay on that subject his friends thought he was "spoofing" them); of butterflies in the Swiss Alps which have no fear of human beings; of Red Admirals (see Color Plate III, figure 3) that seem to delight in barely keeping out of the way of the hunter's net; of combative species, like the American Copper and the Buckeye, that will dart madly, like bees and hornets, at a hat or other object thrown into the air; of other species that play in the air as lambs gambol on the green, with every evidence "of mirth and jocund din."

Again, we might pause to note the tendency of male butterflies to carry sachet bags in their wings to dandify themselves for courting hours; to observe how butterflies are botanists, recognizing the close relatives of their favorite food plants with unerring accuracy; to consider the inexplicable manifestations of instinct that makes the butterfly know the food plants on which its caterpillars feed, although it itself sips nectar from other honey wells.

Then there are such fascinating stories as that of the female Yucca moths, related to our Clothes-moth, upon whom the various species of Yucca are almost entirely dependent for fertilization. These moths not only render an accidental service in transferring pollen from the stamens of one flower to the pistils of another, as do most insects in their nectar-sipping expeditions, but they deliberately, as Professor Riley has demonstrated, collect the pollen in their mouths, which are particularly modified for this task, carry it to the stigma of a flower, and "apply it thereto with infinitely better care than could be done by the most skillful horticulturist, even though he might use the most delicate human appliances."

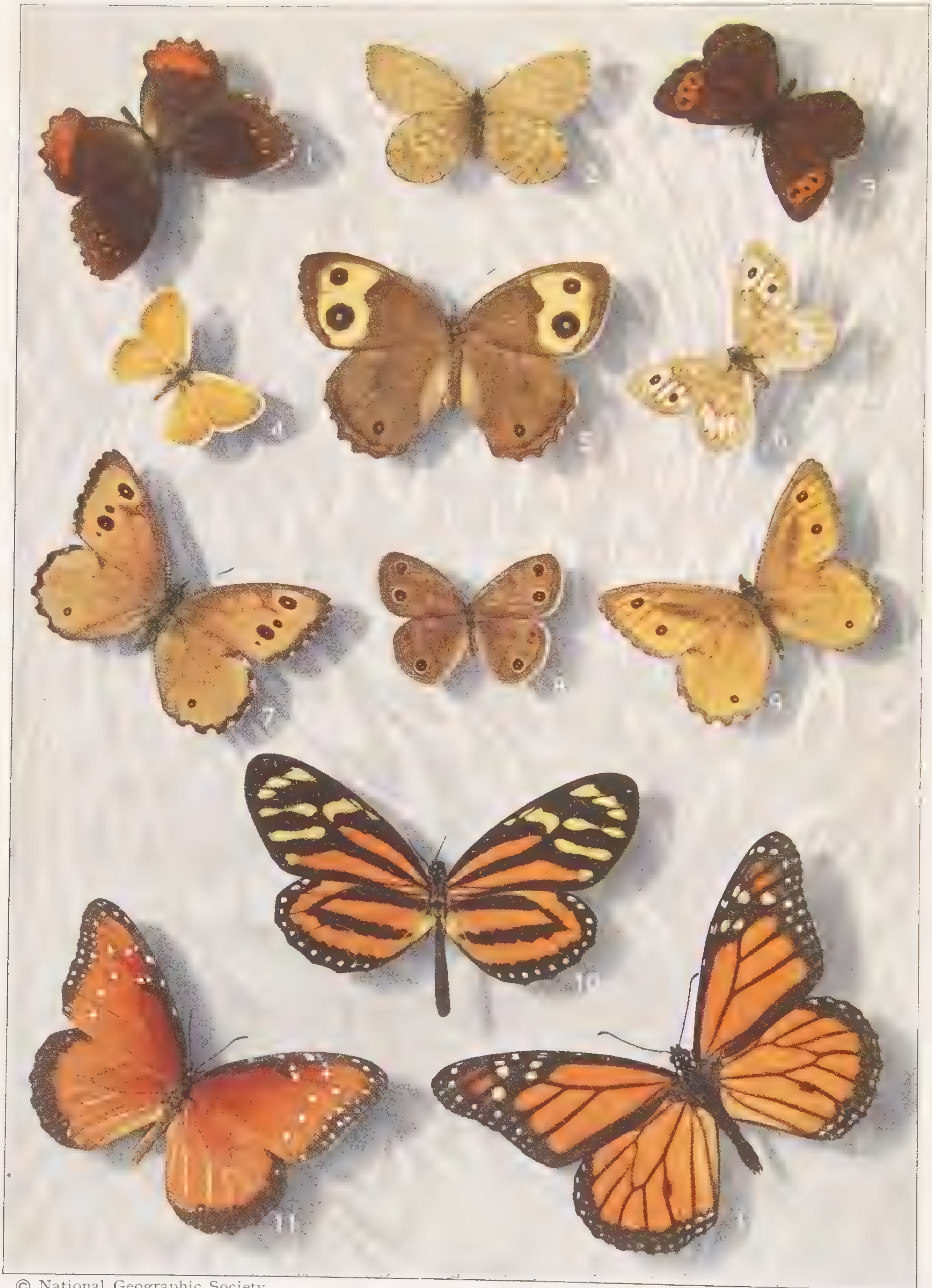
After this task is finished the moth lays her egg in the seed capsule, upon whose tissues her young will feed.

THE ROMANCE OF BUTTERFLY HUNTING

The story of butterfly and moth hunting is filled with romance. Scientists have climbed the mountains and penetrated the jungles of the earth in their quest of these elusive winged rainbows. Numerous lepidopterists have gone to the Tropics to chase innumerable species and to classify and name them.

At home, too, there have been all kinds of adventures. Holland, who has done so much to stimulate interest in the scaly-winged order, tells us of the time when, as a bashful, barefoot boy, he spied his first Diana Fritillary and gave chase.

Up by a boarding school the fluttering creature led him. At every window was a girlish face, and he the most bashful of boys. But his desire to possess the



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Two-thirds Natural Size

ANIMATED GEMS RANGING FROM SATYR TO MONARCH

(1) *Gyrocheilus patrobas* Hew.; (2) White Mountain Butterfly, *Oeneis semidea* Say; (3) Alaskan Alpine, *Erebia disa* Thun.; (4) Ochre Ringlet, *Coenonympha ochracea* Edw.; (5) Grayling, *Cercyonis alope* Fabr.; (6) Ridings' Satyr, *Neominois ridingsi* Edw.; (7) *Oeneis nevadensis* Feld. [Female]; (8) Little Wood-satyr, *Cissia eurytus* Fabr., (9) *Oeneis nevadensis* Feld. [Male]; (10) *Lycorea cleobaea* Godt.; (11) Queen, *Anosia berenice* Cram.; (12) Monarch, *Anosia plexippus* L.

graceful insect was greater than his dread of feminine eyes, and even though the village wag cried after him that the butterfly would not let such a homely boy catch her, he did not relent until he had captured his quarry.

WIDE FIELD IS OPEN FOR AMATEUR RESEARCH

Two young women, wanting to know something more about moths, converted one of their rooms into a "crawlery," where they could watch microscopic caterpillars hatch out of tiny eggs, grow, molt, make cocoons, and finally emerge therefrom as beautiful moths. And from these observations resulted one of the most delightful books in the whole field of natural history.

While tremendous progress has been made in the study of moths and butterflies, there is still opportunity for careful, accurate observation of hundreds of species that dwell in every community, and there remain many gaps to be filled before the story is complete.

The great museums of the world have gathered large collections and individual collectors possess many notable ones.

Occasionally one of these collections goes upon the market for one reason or another, but usually when they pass out of private hands they are presented to such institutions as the United States National Museum, the American Museum of Natural History, and the British Museum; for the creators of these fine individual collections usually are too devoted to their specimens to place a money value upon them. One collector I know is a worker in one of America's greatest museums. He wears cotton socks bought at the 10-cent store, so that he may save money with which to buy specimens for the museum for which public funds are not available.

WHERE OUR MOTHS AND BUTTERFLIES ROAM

THE reproductions of the 16 butterfly and moth plates in four colors, published in this number of the NATIONAL GEOGRAPHIC MAGAZINE, were made possible through the coöperation of the United States National Museum and Dr. Harrison G. Dyar, whose work in the classification of Lepidoptera has been an outstanding achievement in the activities of this great institution.

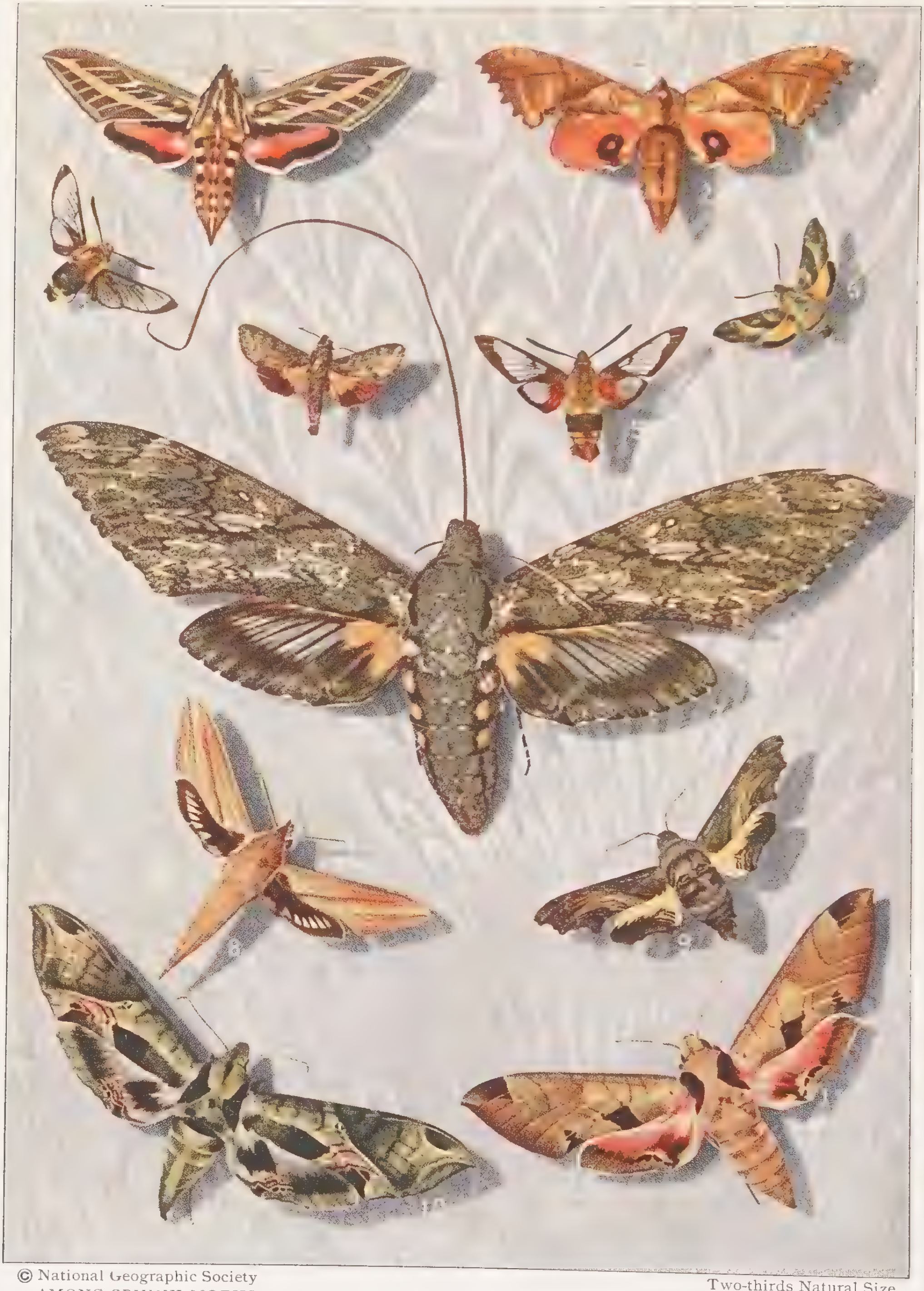
The photographic staff of the National Geographic Society worked out an entirely new system of furnishing the engraver with the color values of the specimens, through which one entire stage in color reproduction was eliminated and consequent loss of color value overcome.

The butterflies and moths here reproduced were selected to show at once the wide range of beautiful color patterns and to aid the everyday reader in becoming better acquainted with the fragile creatures of the air about us. These illustrations present a cross-section of the lepidopterous life of North America, with a few touches of the brilliant tropical life that is always a challenge to color reproduction.

In technical nomenclature the most recent practice has been to subdivide the butterflies into 13 families. Most of the popular field and reference books, however, still adhere to an older classification of five or six families. Lutz and Holland group them into five, and Kellogg into six. Holland and Lutz put the Whites, Sulphurs, and Orange-tips into the family of the Papilionidae with the Swallow-tails, while Kellogg places them in a separate family, called the Pieridae.

Among the moths there are many families—43, according to Holland—but those most frequently observed are the Sphingidae, the Noctuidae, the Arctiidae, the Lithosiidae, the Ceratocampidae, and the Saturniidae. Here, again, different authorities assign various groups to different families.

In these pages the classifications of Lutz and Holland have been followed, as typical of the field books available to the lay reader who wishes to learn something at first hand about the fascinating folk of the moth and butterfly world.



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Two-thirds Natural Size

AMONG SPHINX MOTHS THE GIANT COMMANDS ATTENTION FOR ITS SIZE AND TONGUE

(1) Striped Morning Sphinx, *Celerio lineata* Fabr.; (2) Blinded Sphinx, *Paonias excaecata* A. & S. —also known as *Calasymbolus excaecatus;* (3) Snowberry Clear-wing, *Haemorrhagia diffinis* Bdv.; (4) *Cautethia noctuiformis* Walk.; (5) Humming-bird Clear-wing, *Haemorrhagia thysbe* Fabr.; (6) Clark's Day-sphinx, *Proserpinus clarkiae* Bdv.; (7) Giant Sphinx, *Cocytius antaeus* Dru.; (8) Tersa Sphinx, *Xylophanes tersa* L.; (9) Abbot's Sphinx, *Sphecodina abbotti* Swains.; (10) Satellite Sphinx, *Pholus satellitia* Dru.; (11) Achemon Sphinx, *Pholus achemon* Dru.

Diana Fritillary (*Argynnis diana* Cram. Plate II, figures 1 and 2).—This well-known species belongs to the southern Appalachian region, with a range extending from Virginia and West Virginia to Georgia and South Carolina and westward to the Ozarks, being found in small numbers in southern Ohio and Indiana. The males and females have different markings, as the Plate shows.

Chlosyne lacinia Gey. (Plate II, figure 3).—This species is found occasionally in Texas, Arizona, and Mexico. It belongs to the same general group as the Buckeyes, Wandering Commas, and Crimson-patches.

Heterochroa bredowi Hbn. (Plate II, figure 4).—The range of this species is southern California and Arizona. It is closely related to some of the European butterflies. The larvæ feed on oak.

Euphydryas anicia Dbldy. & Hew. (Plate II, figure 5).—This butterfly, which lacks a common name, is found in the Rocky Mountains and the Pacific States. It is a close relative of our Eastern species, the Baltimore.

Compton Tortoise (*Aglais j-album* Bdv. & Le Con.—also known as *Vanessa j-album*. Plate II, figure 6).—This fair representative of the Tortoise-shell group of butterflies is found from Pennsylvania to Labrador in the East and to Alaska in the Northwest. Its larvæ feed upon willows.

Viceroy (*Basilarchia archippus* Cram. Plate II, figure 7).—The Viceroy gets its everyday name from the fact that it imitates the Monarch. It is found all over the United States as far west as the Sierra Nevada, and sparingly even to the north Pacific coast. The species has two families a year in the northern part of its range. The caterpillar of the autumn brood, when half grown, rolls a leaf, ties it fast to a twig with silk, and then makes a silk couch therein, in which it spends the winter. It feeds on the willow, poplar, aspen, and cottonwood. The Viceroy's mimicry of the Monarch, *Anosia plexippus* (see Color Plate IX, figure 12), affords a striking example of protection by imitation.

Melitaea neumoegeni Skin. (Plate II, figure 8).—This butterfly is found in the mountains of southern California and in the Death Valley region. It belongs to the Checker-spot tribe, and its coloring departs from that of its closer relatives, which inhabit more colorful areas, and is as drab as the region it frequents.

Portia Butterfly (*Anaea portia* Fabr.—also known as *Pyrrhanaea portia*. Plate II, figure 9).—This essentially tropical species occasionally wanders into the southern part of Florida. It is closely related to the Goat-weed Butterfly.

Vanessa carye Hbn. (Plate II, figure 10).—This is a Pacific coast butterfly of the Tortoise-shell group. Its caterpillars live upon malva, hollyhocks, and low ground plants.

Leto Fritillary (*Argynnis lető* Behr. Plate III, figures 1 and 2).—The males and females of this beautiful species have different markings and range the Pacific slope. The Leto is closely related to the Great Spangled Fritillary of the East. The larvæ feed on violets.

Red Admiral (*Vanessa atalanta* L. Plate III, figure 3).—A thorough-going cosmopolite, the Red Admiral is found alike in Europe, Asia, and North America, reaching as far south as Cuba and Guatemala. Its food plants include the nettle and the hop. This butterfly winters both as a chrysalis and as an adult, and the frayed, worn appearance of the latter is in painful contrast to the spick-and-span aspect of that which spends the winter as a chrysalid.

Gulf Fritillary (*Dione vanillae* L. Plate III, figure 4).—The range of this species is from southern Virginia south and westward to Florida and California. Its food plant is the passion-flower. It has a wing-spread of about three inches.

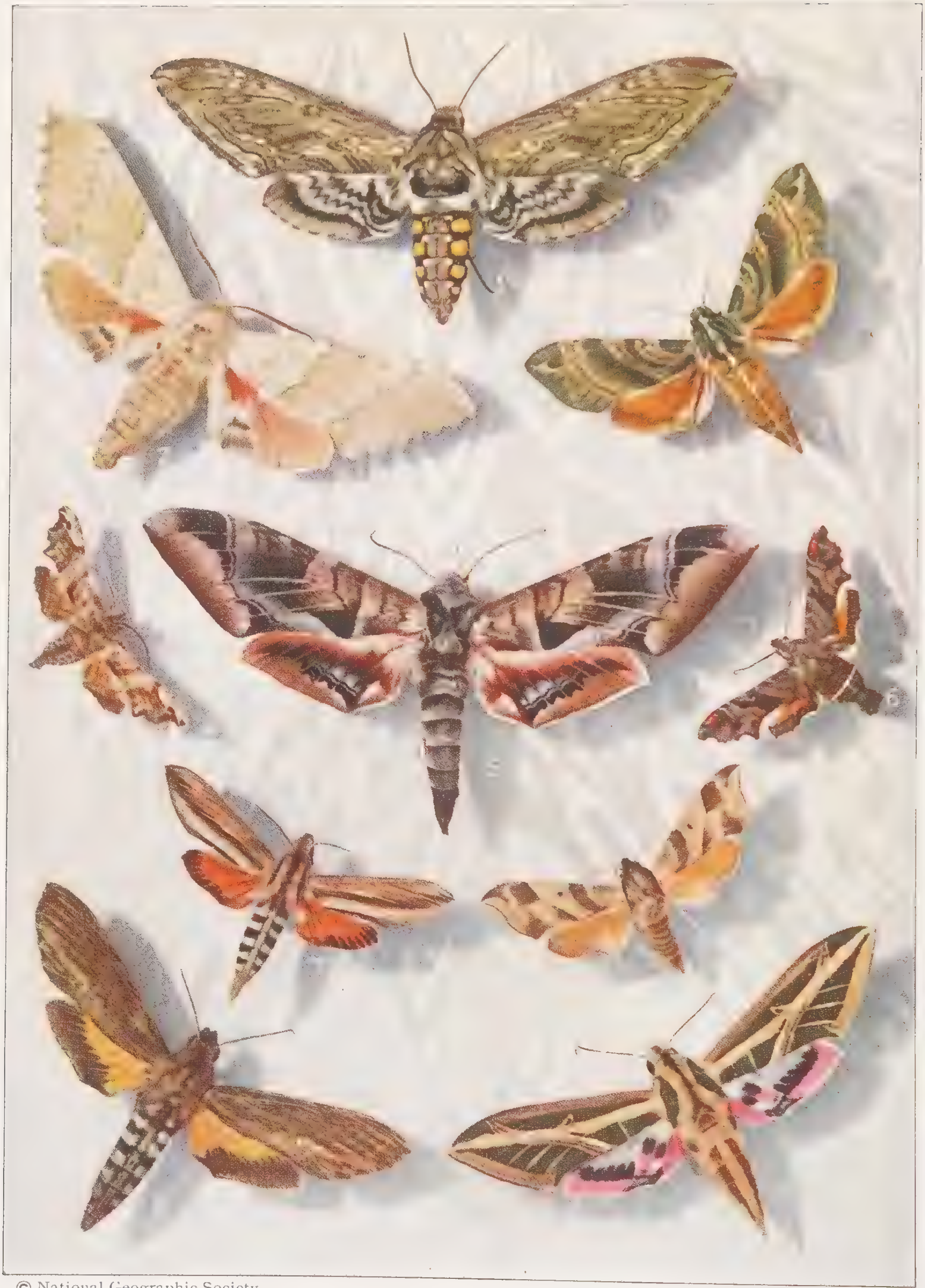
Buckeye (*Junonia coenia* Hbn. Plate III, figure 5).—The Buckeye appears to be the only species of its genus which ventures outside the Tropics; its range extends from Cuba to Massachusetts and westward to the Pacific coast. In warmer areas there are three to four generations a year; in New England only one, and this hibernates as a butterfly. It loves the open fields, and its larvæ feed mainly on plantains and members of the figwort family. It is rather saucy and impudent to other butterflies.

Delila (*Colaenis delila* Fabr. Plate III, figure 6).—The Delila Butterfly is a tropical species which has ventured as far north as southern Texas.

Mourning-cloak (*Aglais antiopa* L.—also known as *Vanessa antiopa*. Plate III, figure 7).—This species is known to nearly every lover of the out-of-doors in the North Temperate Zone. In England its popular name is the Camberwell Beauty. It is the largest of our butterflies which hibernate as adults. When the midwinter thaws occur, one is likely to see in open glades several dark-colored butterflies flitting from tree to tree or resting with expanded wings in sunny spots. These are Mourning-cloaks which have ventured out of their winter retreats, perhaps to die victims of the ensuing cold weather. The eggs are laid in masses circling the twigs of elms, willows, and poplars in late spring, and hatch in about two weeks.

Wandering Comma (*Polygonia satyrus* Edw. Plate III, figure 8).—This species deserves its name as a wanderer. It is found in the Rocky Mountains as far south as New Mexico, and westward to the Pacific from Santa Clara County, California, to Vancouver, British Columbia. It has also been found in Canada—in Ontario, around Montreal and Ottawa—and in Lewis County, New York. Its larvæ feed on stinging nettles.

Regal Fritillary (*Argynnis idalia* Dru. Plate III, figure 9).—Fresh from its pupal case, this lovely member of the Fritillary tribe shows a brilliant sheen of iridescence. It possesses a rather plump body and a wing-spread of about three inches. Having only one generation a year, each stage from egg to adult is more than usually long. Its range is from New England



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Two-thirds Natural Size

THE HAWKMOTHS COMPRISE A BRILLIANT WINGED FAMILY

(1) Five-spotted Hawkmoth, *Protoparce quinquemaculata* Haw.; (2) Big Poplar Sphinx, *Pachysphinx molesta* Harr.; (3) Hydrangea Sphinx, *Ampeloeca versicolor* Harr.—also known as *Darapsa versicolor;* (4) Lettered Sphinx, *Deidamia inscripta* Harr.; (5) *Pholus typhon* Klug.; (6) Nessus Sphinx, *Amphion nessus* Cram.; (7) *Erinnyis caicus* Cram.; (8) Hog Sphinx, *Ampeloeca myron* Cram.—also known as *Darapsa myron;* (9) Alope Sphinx, *Erinnyis alope* Dru.; (10) Lesser Vine Sphinx, *Pholus fasciatus* Sulz.

to Nebraska, in the belt characterized by 50° Fahrenheit as the mean annual temperature. The eggs are laid on the under side of violet leaves, upon which its caterpillars feed, although the butterfly itself is partial to the nectar of joe-pye-weed, boneset, goldenrod, ironweed, and swamp milkweed.

Crimson-patch (*Synchloe janais* Dru. Plate III, figure 10).—This species is largely a tropical one. The northern limits of its habitat reach no farther than Texas, and it is more abundant in Mexico and Central America.

Orange Sulphur (*Eurymus eurytheme* Bdv. Plate IV, figures 1, 2, and 3).—The Orange Sulphur is essentially western in its habitat, though it has been noted in the region of Vancouver in the West, and the valley of the St. Lawrence in the East. The southern limits of its range extend from southern California to Mississippi. It is one of the butterflies which has females of two different types, as shown in the Color Plate.

Cloudless Sulphur (*Catopsilia eubule* L. Plate IV, figures 4 and 5).—The range of this species is from New England and Wisconsin to Patagonia. The region of its greatest abundance is tropical America, where it congregates in great swarms along streams. Other favorite haunts are the orange groves of Florida and Latin America. It will be noted that in the Cloudless Sulphur the female has different markings from the male.

Orange-tip (*Anthocharis sara* Bdv. Plate IV, figure 6).—A true Westerner is this species, belonging to the Mountain States of the Pacific coast. Its early stages appear still to be unknown.

Large Orange Sulphur (*Catopsilia agarithe* Bdv. Plate IV, figure 7).—This species occurs along the shores of the Gulf of Mexico and throughout tropical America. It is closely related to the more familiar Cloudless Sulphur (see figures 4 and 5).

Cabbage Butterfly (*Pieris rapae* L. Plate IV, figure 8).—This species is an imported pest. It appears to have been first introduced into Quebec about 1860 and around New York about 1868. Within 30 years of the time of its introduction it has established itself all over the United States and Canada. Its coming has led to the practical extinction of two native species, the Gray-veined White and the Checkered White, both of which formerly fed on cabbage.

Dog's-head Butterfly (*Zerene caesonia* Stoll.—also known as *Meganostoma caesonia.* Plate IV, figure 9).—This is another species belonging to the tribe of the Yellows. It gets its name from the markings on its wings, which are supposed to resemble a dog's head, although some insist that it looks more like a duck. The range of the species is from Pennsylvania and southern Wisconsin to the Gulf States and Central America, and the food plants of its caterpillars are false-indigo and clover.

Zerene Dog's-head Butterfly (*Zerene eurydice* Bdv. Plate IV, figures 10 and 13).—This is a Pacific coast species whose habits are essentially the same as those of the species immediately preceding.

Clouded Sulphur (*Eurymus philodice* Godt. Plate IV, figure 11).—Everybody knows this species, since no eye is so unobservant as not to have noticed great groups of them holding their little banquets around mud puddles in the road. If one examines the border of the puddle carefully after the butterflies have flown, he will discover the mud full of pinholes where the thirsty creatures have thrust their tongues. The Clouded Sulphur loves the sun. If heavy clouds obscure it, the thousands of butterflies hasten to hide beneath clover or down in the grasses in which they spend the night. Its range is from the mouth of the St. Lawrence River to South Carolina and westward to the Rocky Mountains. There are two forms of the female, the one substituting white where the other wears yellow.

Eurema proterpia Fabr. (Plate IV, figure 12).—Mexico is the usual habitat of this butterfly, though it occasionally crosses the Rio Grande into Texas.

Blue Swallow-tail (*Papilio philenor* L. Plate V, figure 1).—During the summer months this butterfly is found in the Middle Atlantic States. It ranges from Massachusetts to Arizona and southward into Mexico. The caterpillar feeds upon the leaves of the Dutchmans-pipe and Virginia snakeroot.

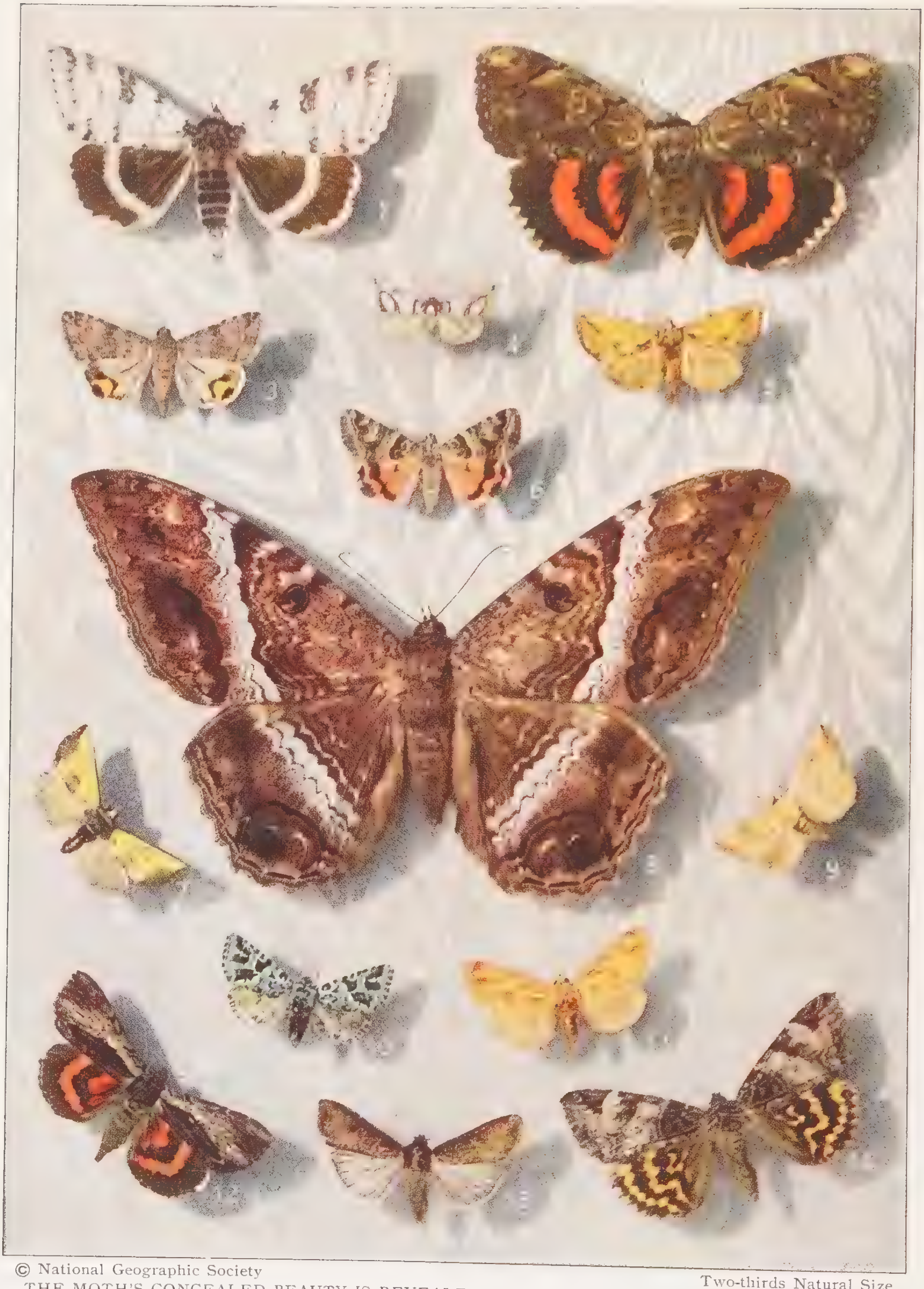
Zebra Swallow-tail (*Papilio marcellus* Cram. —also known as *Iphidicles ajax marcellus.* Plate V, figure 2).—This early spring form is found almost everywhere in the eastern part of the United States, where its caterpillars can find their favorite food, the papaw. It ranges as far north as southern Michigan and in the South passes down to Florida.

Black Swallow-tail (*Papilio polyxenes* Fabr., form *americus* Koll. Plate V, figure 3; form *asterius* Cram., figures 5 and 6).—This butterfly is the adult of the well-known striped parsnip worm and is found generally throughout the eastern United States. The male and female are different in coloration. The form *americus* is a local race from Arizona and Mexico in which the yellow markings are broader.

Giant Swallow-tail (*Papilio cresphontes* Cram. Plate V, figure 4).—While a native of the South, this species is now spreading northward and has been found in Ontario. The orange growers of Florida consider its caterpillar a pest and complain of its ravages upon their trees. The larva is called the "orange dog."

Papilio mylotes Bates. (Plate VI, figures 1 and 6).—This species belongs to a large group of brilliant butterflies the center of whose habitat is the Amazon Valley. Occasional members of the species wander as far north as our Gulf coast.

Tiger Swallow-tail (*Papilio glaucus* L. Plate VI, figure 2; form *glaucus*, figure 3; form *turnus*, figure 5).—On the basis of its wide distribution, the Tiger Swallow-tail would make a lively candidate for our national butterfly. Although its metropolis appears to be in the wooded



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Two-thirds Natural Size

THE MOTH'S CONCEALED BEAUTY IS REVEALED TO THE COLLECTOR (SEE TEXT PAGE 88)

(1) White Birch Under-wing, *Catocala relicta* Wlk.; (2) Darling Under-wing, *Catocala cara* Gn.; (3) *Cirrhobolina mexicana* Behr.; (4) *Chalcopasta koebelei* Riley; (5) *Basilodes pepita* Gn.; (6) *Syneda hastingsi* Edw.; (7) *Stiria rugifrons* Grt.; (8) *Erebus odora* L. [Female]; (9) *Thurberiphaga diffusa* Barn.; (10) *Momophana comstocki* Grt.; (11) *Cirrhophanus triangulifer* Grt.; (12) Ultronia Under-wing, *Catocala ultronia* Hbn.; (13) Variegated Cutworm Moth, *Peridroma margaritosa* Haw.; (14) Clouded Locust Under-wing, *Euparthenos nubilis* Hbn.

forests of the Appalachian Mountains, its range extends from Canada to Key West and the Rio Grande. It affords an example of that form of dimorphism in which females hatched from the same lot of eggs take different colors, although the males always adhere to the one form. The caterpillars, having heads resembling those of serpents (see text, page 91), are found on a great variety of trees and shrubs, including tulip trees, birches, wild cherries, apples, poplars, and ashes.

Parnassian Butterfly (*Parnassius smintheus* Dbldy. & Hew. Plate VI, figure 4).—The Parnassians are Alpine or arctic in habitat. *P. smintheus* is found in the high mountain regions from New Mexico to Montana and thence to the Pacific coast. The caterpillars resemble those of *Papilios*, but are darkly colored and are found wandering on the ground amid the scanty vegetation of their Alpine abode.

Heodes cupreus Edw. (Plate VII, figure 1).—This species is found in dry country, its favorite habitat being eastern Oregon and Wyoming.

Atala (*Eumaeus atala* Poey. Plate VII, figure 2).—This Southern form is found only sparingly in Florida and Cuba. The larva feeds on zamia, one of the few remaining cycads of the Coal Age. The butterflies are all tame and may be hand picked from flowers with a little care.

Wanderer (*Feniseca tarquinius* Fabr. Plate VII, figure 3).—This little Copper is found all over the Atlantic States from Nova Scotia to the Carolinas. It also inhabits the Mississippi Valley. There is but the one species of this genus known. The larva feeds on the masses of white bark-lice found on alder bushes, greatly reducing the numbers of the lice. This is our only carnivorous butterfly.

Great Purple Hair-streak (*Atlides halesus* Hbn.—also known as *Thecla halesus*. Plate VII, figure 4).—The Great Purple Hair-streak is our largest Hair-streak species. It is very common in Central America and Mexico. Although a tropical form, it extends from California to Florida and occasionally occurs as far north as southern Illinois. Its larvæ feed on the mistletoe growing on oaks.

Hypaurotis crysalus Edw. (Plate VII, figure 5).—This is a Western butterfly. It is found generally in California, Utah, and Arizona.

Philotes sonorensis Feld. (Plate VII, figure 6).—This is a Southern butterfly whose range includes southern California and Mexico. It is prized for the curious red markings, so exceptional in one of the Blues.

Bronze Copper (*Heodes thoe* Bdv.—also known as *Chrysophanus thoe*. Plate VII, figures 7, 9, and 10).—This is a rare insect although it occurs in northern Illinois, Nebraska, Iowa, and the upper Mississippi Valley. It has two families a year, and winters as an egg. It finds both goldenrod and Canada thistle much to its liking.

Glaucopsyche lygdamus Dbldy. (Plate VII, figure 8).—Although the exact range of this silvery blue butterfly is not known, it has been found in the Atlantic States from the upper waters of the Susquehanna to Georgia. In its northern range it reaches westward to Ohio, Michigan, and Wisconsin.

Strymon martialis H. S. (Plate VII, figure 11).—The range of this butterfly is very limited; it is found only in southern Florida and the Antilles.

American Copper (*Heodes hypophlaeas* Bdv. Plate VII, figure 12).—These little butterflies are found in the Atlantic States. In the northern part of their range they are double-brooded, and in the southern part triple-brooded. It winters as a chrysalis. It is sorrel in color, matching the sorrel on which it feeds.

Strymon acis Dru. (Plate VII, figure 13).—Southern Florida is the favorite haunt of this butterfly.

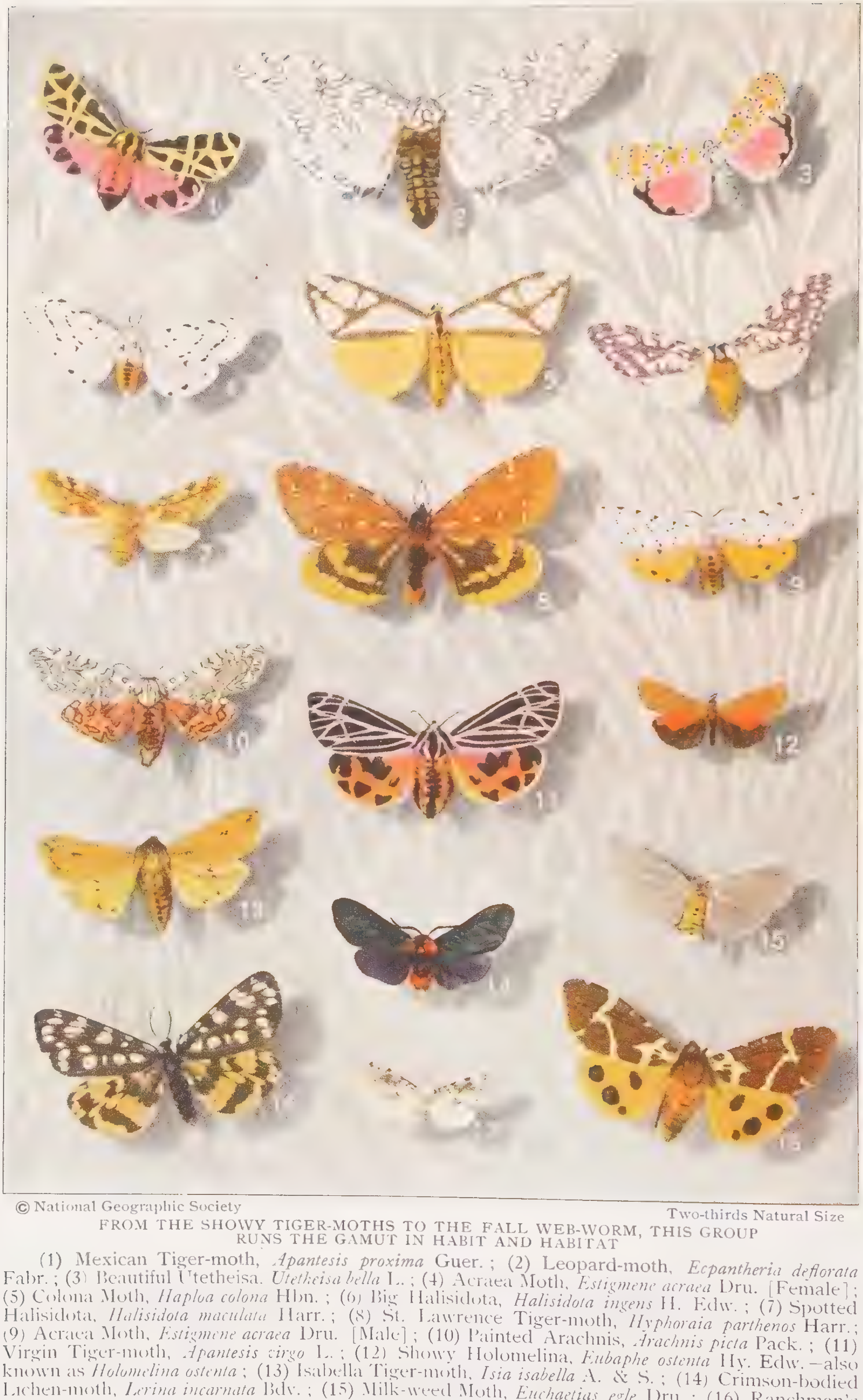
Atalopedes campestris Bdv. (Plate VIII, figure 1).—This butterfly was first found by Boisduval in California. Some authorities have considered it identical with, or at least a variety of, the Sachem or Velvet-spotted Skipper, *Atalopedes huron*, but Scudder declared that the specimens he examined would not permit of such a conclusion. At any rate, it is a very close relative of the Sachem, which ranges from the Catskills of New York to Florida and westward. Its larvæ feed on Bermuda grass, fastening together a number of blades and spinning in the cylindrical cavity thus formed silken webs which serve as retreats, from which they emerge only when feeding.

Arctic Skipper (*Carterocephalus palaemon* Pall.—also known as *Pamphila palaemon* and *Pamphila mandan*. Plate VIII, figure 2).—The range of this butterfly extends from southern Labrador south to the White Mountains and the Adirondacks, and thence westward to the summits of the Sierras in northern California and to southeastern Alaska. Its caterpillars feed on grasses.

Silver-spotted Skipper (*Epargyreus tityrus* Fabr. Plate VIII, figure 3).—The range of the Silver-spotted Skipper reaches from Quebec to Vancouver and as far south as the Isthmus of Panama. It has one generation annually in the North, and is double- or even triple-brooded in the South and within the Tropics. The caterpillar feeds on leguminous plants and is especially fond of wisteria and the locust tree.

Tessellated Skipper (*Pyrgus tessellata* Scud. —also known as *Hesperia tessellata* and *Hesperia montivaga*. Plate VIII, figure 4).—This, one of the commonest of the southern Hesperids, claims the whole of the United States for its range. Its caterpillars feed on hollyhocks, Indian mallows, and related plants.

Eurycides urania W. & H. (Plate VIII, figure 5).—This beautiful butterfly is a tropical species, but on rare occasions individuals have been found within the southern borders of the United States.



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Two-thirds Natural Size

FROM THE SHOWY TIGER-MOTHS TO THE FALL WEB-WORM, THIS GROUP RUNS THE GAMUT IN HABIT AND HABITAT

(1) Mexican Tiger-moth, *Apantesis proxima* Guer. ; (2) Leopard-moth, *Ecpantheria deflorata* Fabr. ; (3) Beautiful Utetheisa. *Utetheisa bella* L. ; (4) Acraea Moth, *Estigmene acraea* Dru. [Female]; (5) Colona Moth, *Haploa colona* Hbn. ; (6) Big Halisidota, *Halisidota ingens* H. Edw. ; (7) Spotted Halisidota, *Halisidota maculata* Harr. ; (8) St. Lawrence Tiger-moth, *Hyphoraia parthenos* Harr.; (9) Acraea Moth, *Estigmene acraea* Dru. [Male]; (10) Painted Arachnis, *Arachnis picta* Pack. ; (11) Virgin Tiger-moth, *Apantesis virgo* L. ; (12) Showy Holomelina, *Eubaphe ostenta* Hy. Edw.—also known as *Holomelina ostenta* ; (13) Isabella Tiger-moth, *Isia isabella* A. & S. ; (14) Crimson-bodied Lichen-moth, *Lerina incarnata* Bdv. ; (15) Milk-weed Moth, *Euchaetias egle* Dru. ; (16) Ranchman's Tiger-moth, *Platyprepia virginalis* Bdv. ; (17) Fall Web-worm Moth, *Hyphantria cunea* Dru.; (18) *Arctia americana* Harr.

Least Skipper (*Ancyloxypha numitor* Fabr. Plate VIII, figure 6).—The smallest of the Skippers is different both in habit and structure from its cousins of the tribe. It is slender-bodied where they are plump and when resting it has a manner of twirling in opposite directions alternately its two antennæ. The eggs are laid in the grass and the butterfly usually floats slowly just above the herbage in sunny places in wet meadows and along the open margins of brooks and marshes. The range of the species extends from Quebec to Florida and westward to the Rocky Mountains.

Megathymus neumoegeni Edw. (Plate VIII, figure 7).—This species has been found in Arizona and Mexico. It is closely related to *M. yuccae*, which is found rather generally distributed in the Southern States. The larvæ bore into the roots and stems of yucca.

Hobomok Skipper (*Poanes hobomok* Harris —also known as *Atrytone zabulon*. Plate VIII, figure 8).—This species ranges from New England to Georgia and westward to the Great Plains, being very common in Pennsylvania and Virginia and along the Ohio River.

Brazilian Skipper (*Calpodes ethlius* Cram. Plate VIII, figure 9).—The Brazilian Skipper might be called a guest from the Tropics, as its southern range reaches to Argentina. It occurs as far north as South Carolina, is abundant around the Gulf of Mexico, and there is a record that one individual was taken some years ago in New York State. Almost every year we find some of the larvæ on the ornamental cannas in Washington, D. C. Its powers of flight must be considerable, as it is killed off every winter in the North.

Long-tailed Skipper (*Goniurus proteus* L.—also known as *Eudamus proteus*. Plate VIII, figure 10).—This is another tropical species which has ventured into the temperate regions and is found occasionally as far north as New York City. Its caterpillar feeds on wisteria and the butterfly-pea, beans, etc., cutting a flap out of the corner of a leaf which it folds over and fastens with a few strands of silk.

Gyrocheilus patrobas Hew. (Plate IX, figure 1).—This species is found in Mexico and Arizona. It is a close relative of the Arizona Blackamoor, *G. tritonia,* which has the same general range.

White Mountain Butterfly (*Oeneis semidea* Say. Plate IX, figure 2).—As pointed out in the text on page 103, this butterfly has a remarkably restricted habitat in the United States, appearing only on the summit of Mt. Washington. It is a survival of the Ice Age in those regions, and reaches the lower areas only in Labrador and the far North. Another colony has been left on Mt. Katahdin, Maine, differing a little in color from those on Mt. Washington.

Alaskan Alpine (*Erebia disa* Thun. Plate IX, figure 3).—The Alaskan Alpine is found in Alaska and on the mountains of British Columbia. Its larval stage has not been discovered.

Ochre Ringlet (*Coenonympha ochracea* Edw. Plate IX, figure 4).—The Ochre Ringlet has a range extending from British Columbia to Arizona and reaching as far east as Kansas. Although a small butterfly, it belongs to a genus that is widely distributed throughout the temperate regions of both the New and the Old World. It is often seen flying in dry herbage, which its colors simulate.

Grayling (*Cercyonis alope* Fabr. Plate IX, figure 5).—This species occurs from the Atlantic to the Pacific and has several varieties, among them the Blue-eyed, the Dull-eyed, the Hybrid, and the Sea-coast Graylings. The blue-eyed variety is a lover of lonely lanes and bramble-covered walls and fences as well as of the open woods. It visits the hardhacks in the East and the tickseed on the plains of the West. Its caterpillar hibernates without eating after hatching. The dull-eyed variety is simply a Northern variation of the blue-eyed. Comstock describes the Hybrid Graylings as the progeny of the yellow-banded beauty of the South and the sad-colored Puritan of the North.

Ridings' Satyr (*Neominois ridingsi* Edw. Plate IX, figure 6).—Ridings' Satyr is found in the Mountain States of the Pacific coast. Its eggs are somewhat barrel-shaped, broader at the base than at the top, and with a rounded summit.

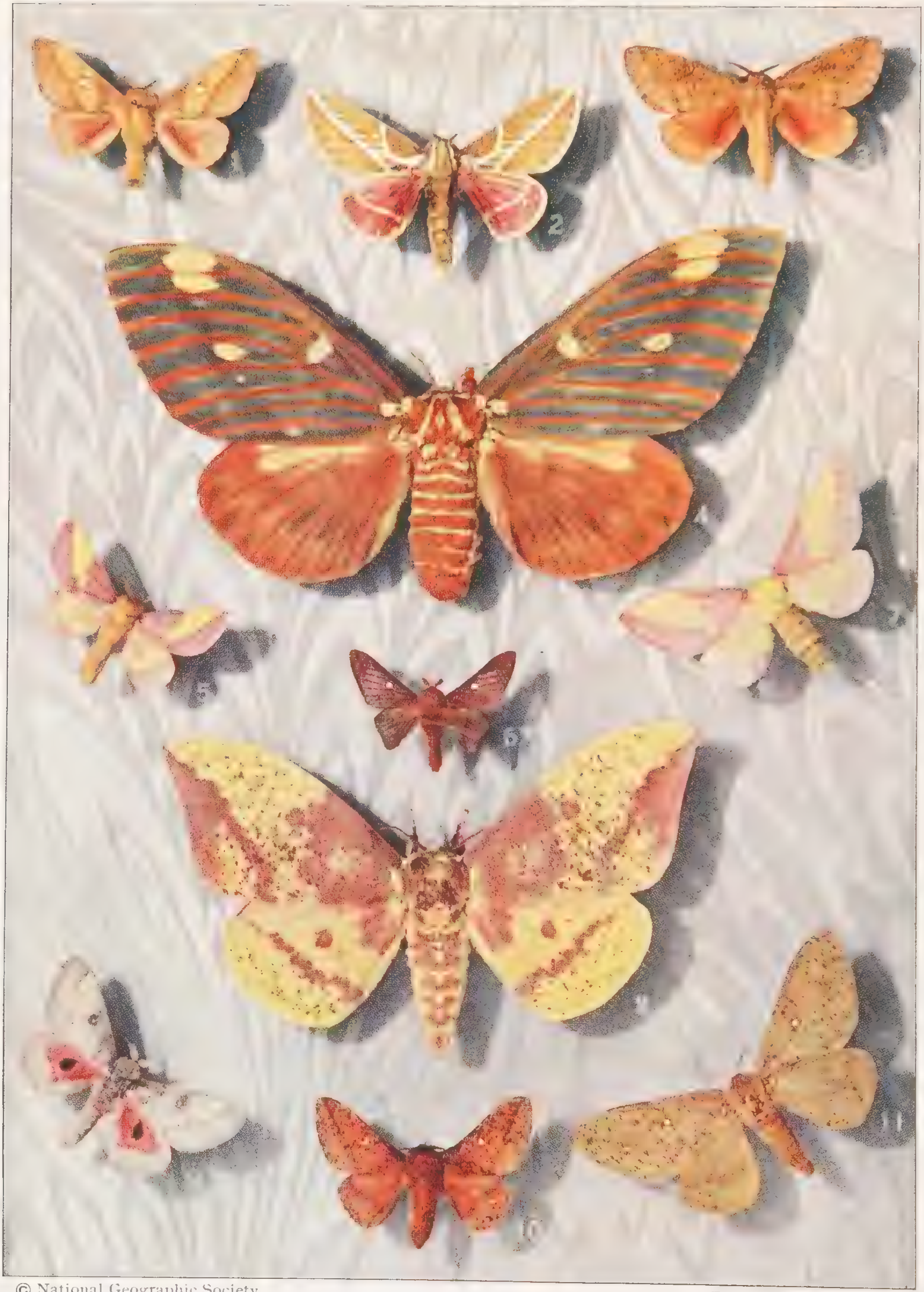
Oeneis nevadensis Feld. (Plate IX, figures 7 and 9).—This species occurs in the Pacific States, the male and female differing somewhat in appearance, as is shown in the Color Plate. It is an inhabitant of the higher hills.

Little Wood-satyr (*Cissia eurytus* Fabr. Plate IX, figure 8).—The Little Wood-satyr is one of the most vivacious species of the genus to which it belongs. It loves the shades of thickets and groves. A peculiar thing about its eye spots is that when looked at directly from above they seem solid, but when looked at from an angle they show double pupils of metallic sheen. The species is single-brooded and puts in an early spring appearance. Its caterpillars feed by night and hide during the day among the roots and bases of grass.

Lycorea cleobaea Godt. (Plate IX, figure 10).—This species is essentially a tropical one which occasionally reaches as far north as southern Florida. Its brilliant colors are mimicked in the Tropics by the delicate Heliconias.

Queen (*Anosia berenice* Cram. Plate IX, figure 11).—*Anosia berenice* is a Southern species with a range that includes the Gulf States, New Mexico, and Arizona. The Vicereine imitates the Queen just as the Viceroy copies the Monarch. The caterpillars are found on a climbing milkweed.

Monarch (*Anosia plexippus* L. Plate IX, figure 12).—The Monarch is one of the world's greatest butterfly travelers. With the advent of spring it presses northward from the Far South until it reaches the latitude of lower Canada. In the fall the northern clans gather and press southward, calling millions of recruits to their standards as they go, until the swarming hosts literally cover the trees upon which they rest during the night. It has crossed the seas, following the trade routes, and has succeeded in



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Two-thirds Natural Size

THE ROYAL WALNUT-MOTH, THE IMPERIAL MOTH, AND SOME OF THEIR SMALL COUSINS

(1) *Aaelocephala isias* Bdv.; (2) White-lined Syssphinx, *Adelocephala albolineata* G. & R.—also known as *Syssphinx albolineata;* (3) Honey-locust Moth, *Adelocephala bicolor*, Harr.; (4) Royal Walnut-moth, *Citheronia regalis* Fabr.; (5) Rosy Maple-moth, *Anisota rubicunda* Fabr. [Male]; (6) Orange-striped Oak-worm Moth, *Anisota senatoria* A. & S.; (7) Rosy Maple-moth, *Anisota rubicunda* Fabr. [Female]; (8) Imperial Moth, *Eacles imperialis;* Dru.—also known as *Basilona imperialis;* (9) Heiligbrodt's Syssphinx, *Adelocephala heiligbrodti* Harv.—also known as *Syssphinx heiligbrodti;* (10) Stigma Moth, *Anisota stigma* Fabr. [Male]; (11) Stigma Moth, *Anisota stigma* Fabr. [Female].

establishing itself in Australia, Java, Sumatra, and the Philippines. Likewise, it has gained a foothold in England and the Cape Verde Islands. It has traveled across the seas probably as a stowaway in the chrysalis stage, in packing material. The larva is the common striped milkweed caterpillar with its shaking black horns.

Striped Morning Sphinx (*Celerio lineata* Fabr. Plate X, figure 1).—The range of the Striped Morning Sphinx, which is probably the commonest of all the North American sphinx moths, extends from southern Canada to Cuba and Central America. The moth flies in the sunshine and is frequently found swarming around electric street lights in the evening. The caterpillars feed upon the various species of the purslane family, including the flame flower, the Virginia springbeauty, and the ordinary purslane of the garden. The moths visit the blossoms of thistles and of the soapwort in their search for nectar.

Blinded Sphinx (*Paonias excaecata* A. & S.—also known as *Calasymbolus excaecatus*. Plate X, figure 2).—The range of this species extends from southern Canada to Florida and westward to the Great Plains. Its caterpillars feed upon the willow, hazel, ironwood, and other allied trees and shrubs.

Snowberry Clear-wing (*Haemorrhagia diffinis* Bdv. Plate X, figure 3).—This species has a range that extends from New England to Georgia and westward to the Dakotas and Oklahoma. It occurs in three forms, one in the spring and two in the summer. Its caterpillars feed upon snowberries, honeysuckles, and the like.

Cautethia noctuiformis Walk. (Plate X, figure 4).—This is a tropical species, and although it has been seen in southern Florida, it only occasionally comes farther north than Cuba.

Humming-bird Clear-wing (*Haemorrhagia thysbe* Fabr. Plate X, figure 5).—The Humming-bird Clear-wing is the largest and commonest species of the genus to which it belongs. Its caterpillars feed upon viburnum and kindred plants, and the insect's range reaches from Nova Scotia and Canada to Florida and the Mississippi River.

Clark's Day-sphinx (*Proserpinus clarkiae* Bdv. Plate X, figure 6).—Clark's Day-sphinx has a range that extends from Utah and Montana northward into northern California and Oregon.

Giant Sphinx (*Cocytius antaeus* Dru. Plate X, figure 7).—The Giant Sphinx, famous for its magnificent tongue, has a range that extends from Florida into southern Brazil. The larvæ are large green worms with a horn near the tail, feeding upon plants of the custard-apple family.

Tersa Sphinx (*Xylophanes tersa* L. Plate X, figure 8).—This species is a common and easily recognized one, possessing a range that extends from southern Canada to northern Argentina. Its peculiar tapering body gives it a graceful appearance.

Abbot's Sphinx (*Sphecodina abbotti* Swains. Plate X, figure 9).—This, one of the beauties of the Hawkmoth group, has a range that extends throughout the Eastern States and southern Canada and as far westward as Iowa and Kansas. The larvæ occur in two forms, one with large green moon-shaped spots, the other plain brown, and are found on woodbine and grape.

Satellite Sphinx (*Pholus satellitia* Dru. Plate X, figure 10).—The Satellite Sphinx is widely distributed throughout the eastern United States and southern Canada. During the first several molts the caterpillar is green. In the later stages of development it frequently becomes dark brown. The genus to which the Satellite belongs embraces 19 species. The caterpillars have the body large in front, into which they can draw the head. They are red or green, with white spots on the sides, and occur on the woodbine and grape.

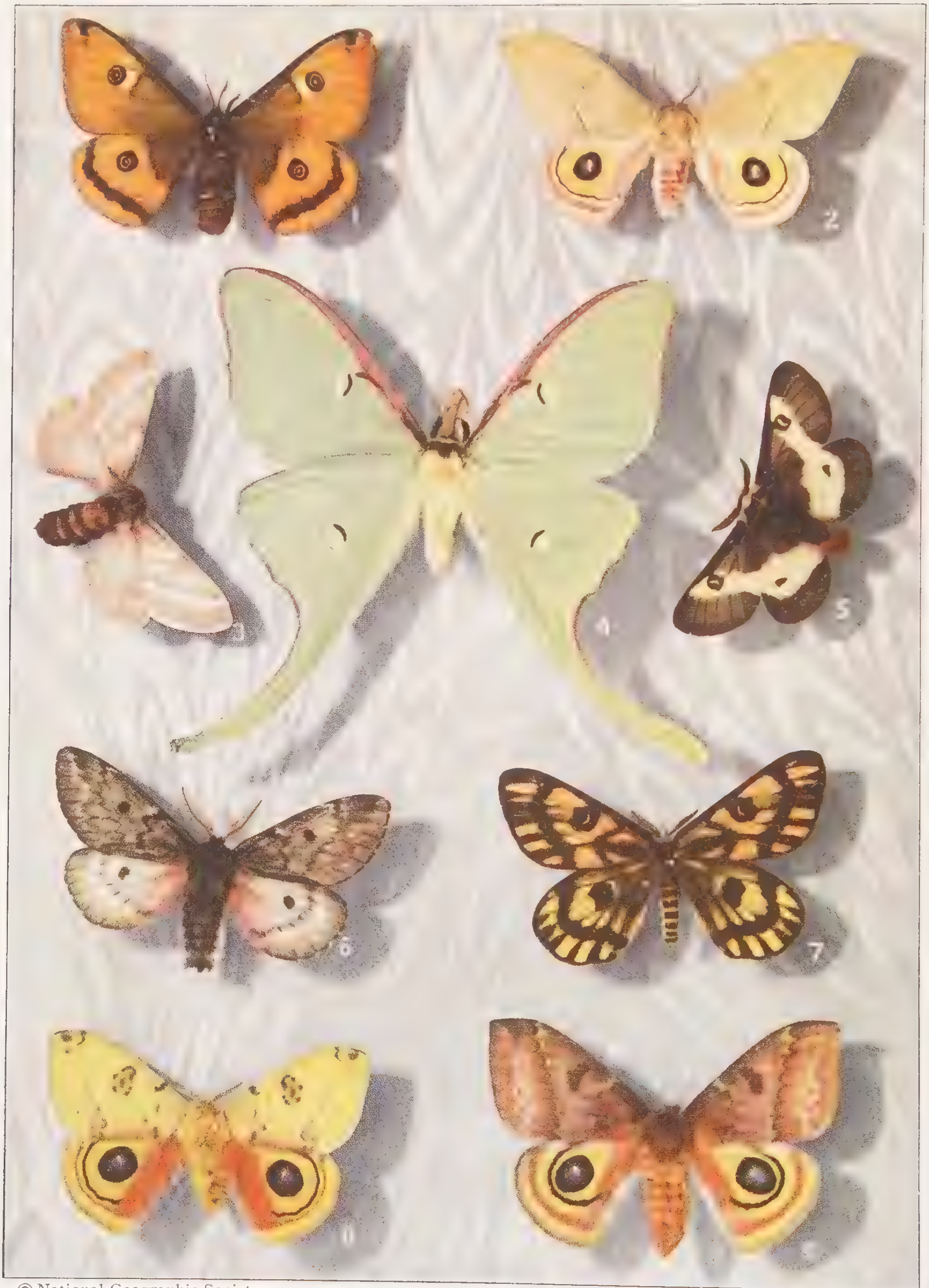
Achemon Sphinx (*Pholus achemon* Dru. Plate X, figure 11).—The Achemon Sphinx has a range that includes all of the United States, southern Canada, and the northern part of Mexico. Its caterpillars feed upon vines and show a special fondness for grapes. The Virginia creeper is another of its food plants. It is very much like the caterpillar of the Satellite Sphinx, except that the white spots on the sides are of another shape.

Five-spotted Hawkmoth (*Protoparce quinquemaculata* Haw. Plate XI, figure 1).—This species is very common, particularly in the South, where, because of its larva's attack upon the tobacco plant, it has long been known as the tobacco fly. Many species of the potato family are to the liking of its larvæ. The green caterpillars with a horn near the tail are easily recognized.

Big Poplar Sphinx (*Pachysphinx modesta* Harr. Plate XI, figure 2).—The Big Poplar Sphinx is one of the noblest of the Hawkmoths. It ranges over the entire United States and its caterpillars feed on poplars, willows, and kindred trees. There are several varieties of this species, the Western one being paler than that which dwells in the East, to match better the lighter colors of the dry western plains.

Hydrangea Sphinx (*Ampelocca versicolor* Harr.—also known as *Darapsa versicolor*. Plate XI, figure 3).—There are few lovelier moths than this beautiful species, which ranges from New England to South Carolina and westward toward the Mississippi River. Its caterpillars feed upon the wild hydrangea, which is found in deep, wooded glens, along the margins of small streams.

Lettered Sphinx (*Deidamia inscripta* Harr. Plate XI, figure 4).—This "learned" member of the Sphinx family is a common species in western Pennsylvania, but is not often encountered in the remainder of its range, which



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Two-thirds Natural Size

THE NIGHT-FLYING LUNA (4) IS THE PREMIER BEAUTY OF THE MOTH WORLD

(1) Mendocino Silk-moth, *Saturnia mendocino* Behr.; (2) Pamina Moth, *Hyperchiria pamina* Neum. —also known as *Automeris pamina;* (3) Range Caterpillar Moth, *Hemileuca oliviae* Ckll.; (4) Luna Moth, *Actias luna* L.; (5) Buck moth, *Hemileuca maia* Dru.; (6) Pandora Moth, *Coloradia pandora* Blake; (7) *Pseudohazis eglanterina* Bdv.; (8) Io Moth, *Hyperchiria io* Fabr. [Male]—also known as *Automeris io;* (9) Io Moth, *Hyperchiria io* Fabr. [Female]—also known as *Automeris io.*

extends from Canada to Virginia and westward to the Mississippi. Its caterpillar feeds upon the wild grapevine and woodbine.

Pholus typhon Klug. (Plate XI, figure 5).—This species has a limited distribution, being reported only from Arizona and Mexico. It is a close relative of the Satellite Sphinx (see Color Plate X).

Nessus Sphinx (*Amphion nessus* Cram. Plate XI, figure 6).—Ranging from Canada to Georgia and thence westward to the Rocky Mountains, this Sphinx is a day flyer. The wild grape is one of its favorite food plants.

Erinnyis caicus Cram. (Plate XI, figure 7).—This is a tropical species which occurs occasionally in Florida. It is marked like its close cousin, the Ello Sphinx, which is the commonest of all the Hawkmoths of the American Tropics and has straggled as far north as Canada.

Hog Sphinx (*Ampeloeca myron* Cram.—also known as *Darapsa myron.* Plate XI, figure 8).—The Hog Sphinx is a resident of the Atlantic States, but its range extends as far west as Kansas and Iowa. Its caterpillars feed upon wild and domestic grapevines and the Virginia creeper; but they never become sufficiently numerous to do serious damage, since certain species of ichneumon flies employ them as larders for their own young. The female flies deposit their eggs upon the skin of the young caterpillar. When these hatch the larvæ penetrate the skin of the host, and before the latter has reached maturity are ready to pupate themselves, which they do by weaving little white cocoons on the backs of the caterpillars. Those which escape this parasitization make themselves loose cocoons of closely woven threads of silk, spun under leaves at the surface of the ground, which is the orthodox method of many Hawkmoths.

Alope Sphinx (*Erinnyis alope* Dru. Plate XI, figure 9).—This is another tropical species which occurs in southern Florida and possesses typical Hawkmoth attributes.

Lesser Vine Sphinx (*Pholus fasciatus* Sulz. Plate XI, figure 10).—The Lesser Vine Sphinx is quite common in the Gulf States, though more abundant in tropical Latin America. Stragglers of the species have been taken as far north as Massachusetts.

White Birch Under-wing (*Catocala relicta* Wlk. Plate XII, figure 1).—This is one of the Under-wing moths, which have bright colors on the hind wings that do not appear when the insect is at rest. This species frequents the birch trees, and its folded wings perfectly simulate the markings of the birch bark. Its range includes most of the northern Atlantic States area.

Darling Under-wing (*Catocala cara* Gn. Plate XII, figure 2).—The Darling Under-wing is a native of the Appalachian area. Frequenting the maples as *C. relicta* frequents the birches, its forewings are shaded to give it protective coloration when resting on the maple.

Cirrhobolina mexicana Behr. (Plate XII, figure 3).—This species has a range extending from Colorado and Texas into Arizona and the plateaus of Mexico. It belongs to that same family of moths, the *Noctuidae,* which gives us so many of our army worms and cutworms.

Chalcopasta koebelei Riley (Plate XII, figure 4).—This species is an inhabitant of the arid Southwest, Death Valley being included in its range.

Basilodes pepita Gn. (Plate XII, figure 5).—This is another of the family of *Noctuidae,* whose range extends from Pennsylvania to Florida and westward to Colorado.

Syneda hastingsi Edw. (Plate XII, figure 6).—This member of the family of Noctuids is found in California and Oregon. The moths fly about in the day, alighting on the ground, when the brilliant colors of the hind wings are hidden and they resemble the dust on which they rest.

Stiria rugifrons Grt. (Plate XII, figure 7).—This species has been found in southern Indiana, Kansas, and Colorado. Little is known about the various stages of its existence.

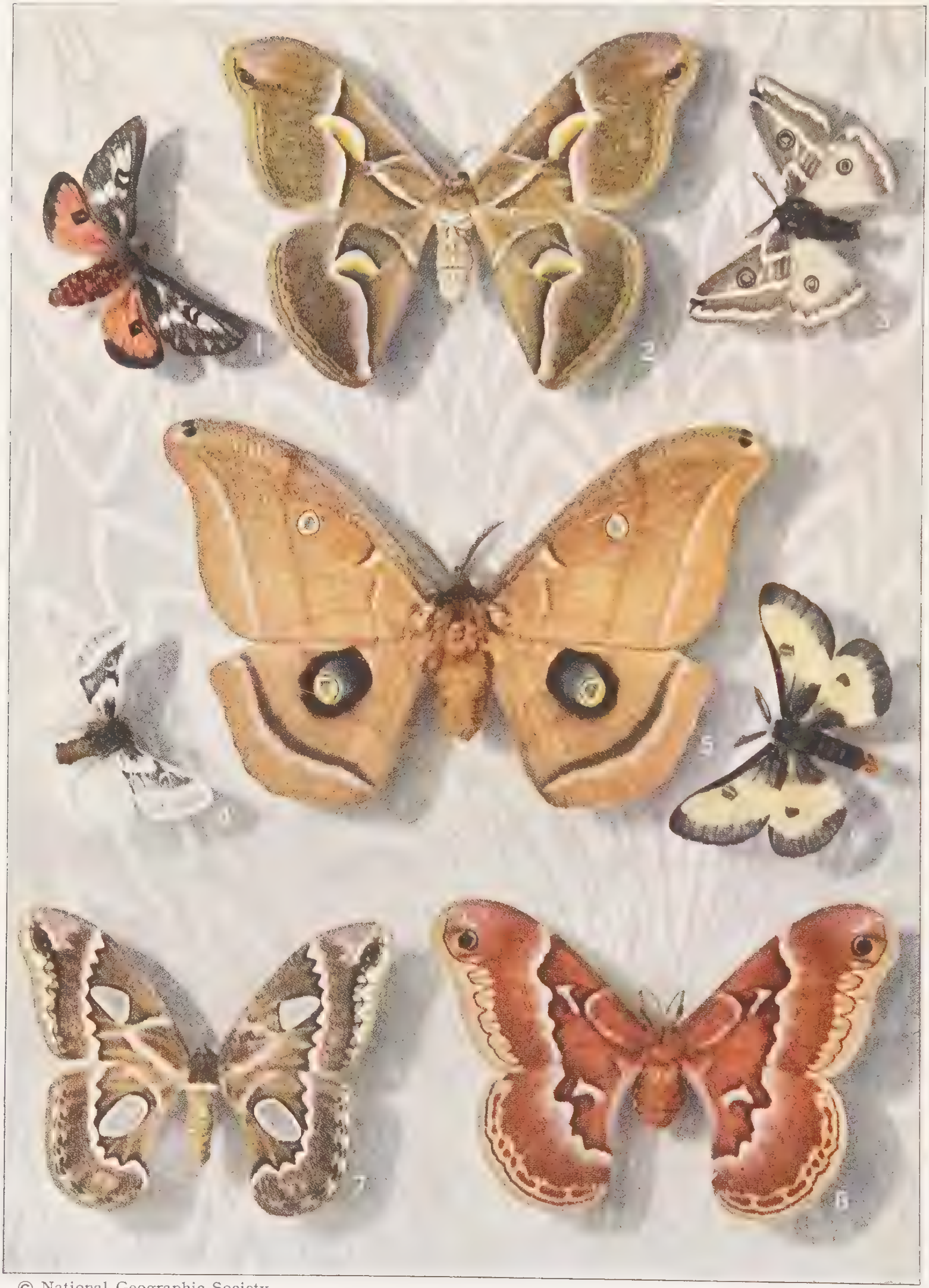
Erebus odora L. (Plate XII, figure 8).—Compared with many of the lesser Noctuids, this magnificent species, the only one of the genus appearing in the United States, is a charming insect. It occurs quite abundantly in the warm areas around the Gulf of Mexico and is sometimes found as a straggler even as far north as Canada. It is widely distributed throughout tropical America. It does not breed in the United States, our examples all being visitants.

Thurberiphaga diffusa Barn. (Plate XII, figure 9).—This is a rare species found in Arizona and New Mexico. The moth flies about the time the wild cotton is in bloom and hides in the flower when resting.

Momophana comstocki Grt. (Plate XII, figure 10).—This is a rare species. All of the specimens that have been taken have been found in New York and Canada, but these have been so few that the species is missing from many museums.

Cirrhophanus triangulifer Grt. (Plate XII, figure 11).—This member of the Noctuid family is found in the Southern States and also as far north as Pennsylvania.

Ultronia Under-wing (*Catocala ultronia* Hbn. Plate XII, figure 12).—This species possesses a number of forms, the one shown being perhaps the commonest. It occurs from Canada to Florida and westward to the Great Plains. The moths alight on tree trunks, which the colors of their upper wings resemble.



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Two-thirds Natural Size

THE AILANTHUS SILK-MOTH (2) IS AN EMIGRANT FROM ASIA

(1) *Hemileuca electra* Wright; (2) Ailanthus Silk-moth, *Samia cynthia* Dru.—also known as *Philosamia cynthia;* (3) *Agapema anona* Ottol.; (4) Tricolor Buck-moth, *Hemileuca tricolor* Pack.; (5) Polyphemus Moth, *Telea polyphemus* Cram.; (6) Nevada Buck-moth, *Hemileuca nevadensis* Stretch; (7) *Rothschildia jorulla* West.; (8) Spice-bush Silk-moth, *Callosamia promethea* Dru.

Variegated Cutworm Moth (*Peridroma margaritosa* Haw. Plate XII, figure 13).—This species is one of about a dozen of the genus found in the United States. It is the moth of the common variegated cutworm, so destructive to grass and low vegetation.

Clouded Locust Under-wing (*Euparthenos nubilis* Hbn. Plate XII, figure 14).—This is a somewhat rare species which occurs from the northern Atlantic States to Arizona. The caterpillars frequent the locust trees and are colored like the bark on which they rest.

Mexican Tiger-moth (*Apantesis proxima* Guer. Plate XIII, figure 1).—The Mexican Tiger-moth occurs in southern California, Arizona, Mexico, and Central America. The genus to which it belongs is essentially an American one, there being only two species attributed to it in the Old World. Its family, the *Arctiidae*, includes more than 2,000 species, being represented in North American life by 38 genera, subdivided into about 120 species.

Leopard-moth (*Ecpantheria deflorata* Fabr. Plate XIII, figure 2).—This species ranges from southern New England into Mexico, being rare in its northern territory and abundant in the southern part of its range. The big black red-banded caterpillar covered with coarse black bristles is very striking but not often found.

Beautiful Utetheisa (*Utetheisa bella* L. Plate XIII, figure 3).—A visitor to the blossoms of the goldenrod, *U. bella* is seen in the late summer and fall in the States of the Atlantic seaboard. The only other member of the genus to which it belongs found within the United States is *U. ornatrix*, which occurs in southern Florida. The larvæ live in open webs, resembling spiders' webs, on wild-indigo and similar plants.

Acraea Moth (*Estigmene acraea* Dru. Plate XIII, figures 4 and 9).—This moth is one of the most frequently occurring in the Middle Atlantic States. There are several varieties and the two sexes wear different clothes. The larvæ are the brown "woolly bears" so often seen in lawn and garden.

Colona Moth (*Haploa colona* Hbn. Plate XIII, figure 5).—The Colona Moth is the largest species of its genus. Although found occasionally in the North Atlantic States and more frequently in the South Atlantic group, it is most abundant in the region of which Texas is the center. It occurs in local colonies, abundant where found, absent elsewhere. The species of its genus are noted for their lack of consistency in color reproduction, it being somewhat difficult to find a group of individuals possessed of uniform markings. Heredity clearly has not yet set their colors.

Big Halisidota (*Halisidota ingens* H. Edw. Plate XIII, figure 6).—This species is found in the Rocky Mountains and in Arizona. It belongs to an extensive genus well represented in Central and South America and containing about a dozen species within the territory of the United States. It belongs to a group of species the larvæ of which feed on spruce and hemlock.

Spotted Halisidota (*Halisidota maculata* Harr. Plate XIII, figure 7).—The Spotted Halisidota has a range that covers the northern part of the United States. The black and yellow tufted caterpillars are often seen on willow and alder in the fall.

St. Lawrence Tiger-moth (*Hyphoraia parthenos* Harr. Plate XIII, figure 8).—The St. Lawrence Tiger-moth belongs to a subarctic genus which is distributed in the subarctic areas of North America, Asia, and Europe. The present species occurs most frequently in the St. Lawrence Valley, northern New England, and westward to Manitoba. Occasionally it is found in the Catskills.

Painted Arachnis (*Arachnis picta* Pack. Plate XIII, figure 10).—This species is found in Colorado, southern California, and northern Mexico. The food plants of its caterpillars are the lupines and their relatives, though they are rather general feeders on low plants. The caterpillars are black covered with dense spiny hairs.

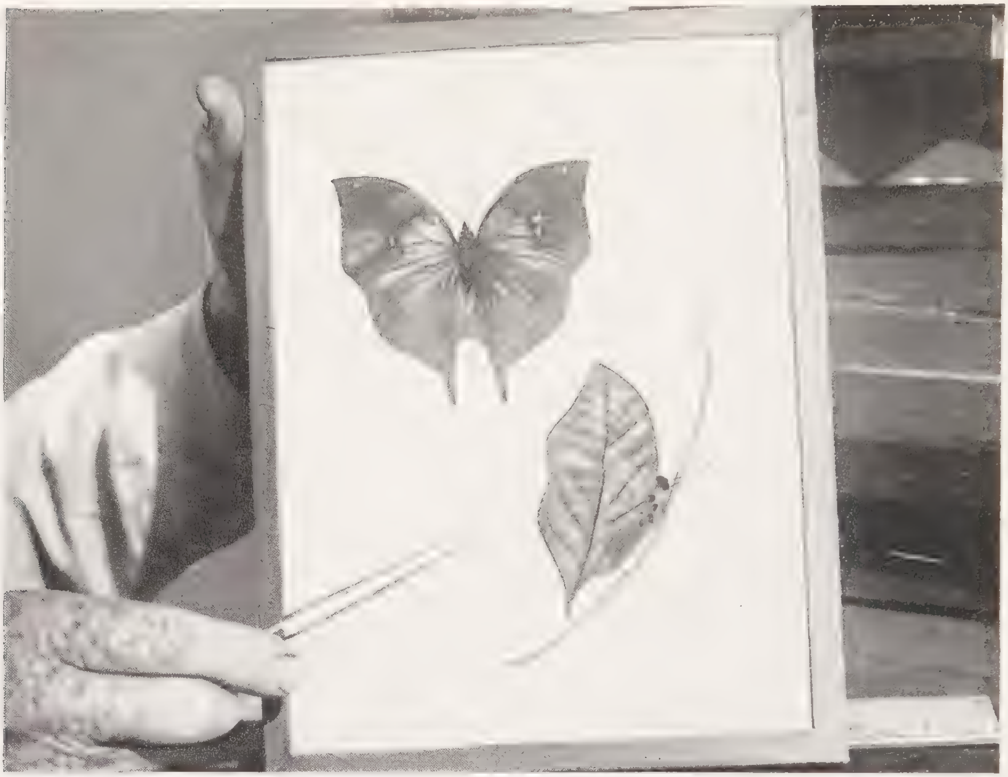
Virgin Tiger-moth (*Apantesis virgo* L. Plate XIII, figure 11).—The Virgin Tiger-moth is a resident of the northern Atlantic States and Canada. The cream-colored stripes on the black wings made the pioneer American entomologist, T. W. Harris, think of a horse's leather harness, and he named one species of the genus *phalerata* "harnessed."

Showy Holomelina (*Eubaphe ostenta* Hy. Edw.—also known as *Holomelina ostenta*. Plate XIII, figure 12).—As its name implies, the Showy Holomelina is a splendidly colored insect. It has been found in Colorado, New Mexico, Arizona, and across the Rio Grande. Little is known of its life history.

Isabella Tiger-moth (*Isia isabella* A. & S. Plate XIII, figure 13).—The Isabella Tiger-moth is the adult of the clipped woolly bear, the fore part of whose body is covered with black hairs, as is also the tail, but the third quarter of which wears a beautiful surcingle of red, all the hairs of the same length. Lutz says that experiments made by him indicated that those which appear after wet spells wear more black than those which follow dry weather, but this surmise is doubtful.

Crimson-bodied Lichen-moth (*Lerina incarnata* Bdv. Plate XIII, figure 14).—This species is a resident of Arizona and Mexico and is so different from all other species that a special genus was set up by classifiers for its accommodation.

Milk-weed Moth (*Euchaetias egle* Dru. Plate XIII, figure 15).—The Milk-weed Moth claims most of the United States east of the Rocky Mountains as its territory. Its pretty caterpillars are tufted with black, white, and orange, and may be found, many together, on



Photograph from International Newsreel

A KALLIMA BUTTERFLY ON THE WING AND AT REST

Note how this native of India when alight simulates a leaf on a twig (see text, page 88).

Photograph by Charles Martin

WHERE THE NATIONAL MUSEUM PRESERVES ITS MOTHS AND BUTTERFLIES

There are many insect foes of museum specimens which must be constantly guarded against by the use of naphthalene preparations.

the backs of milkweed leaves, their favorite food. Be careful when you turn the leaf or they will all drop off.

Ranchman's Tiger-moth (*Platyprepia virginalis* Bdv. Plate XIII, figure 16). — Occupying what was formerly the cowboy country of the West, this species came by its name of Ranchman's Tiger-moth quite naturally. It is common in Colorado, Wyoming, and Montana, and is found in the latitude of these States to the Pacific coast. The larvæ are found in grass and garden. They look like our "woolly bears," but the hair is softer.

Fall Web-worm Moth (*Hyphantria cunea* Dru. Plate XIII, figure 17).—The range of the Fall Web-worm Moth extends from southern New England to Texas and westward. Its larvæ spin great webs in the foliage of almost all kinds of deciduous trees in the summer and fall, and do much damage to shade trees in nurseries and orchards, the apple and the ash being among its favorites. There is a considerable variation in the markings of both larvæ and adults. The pupa weaves a loose cocoon and hibernates in crevices of brick, porous soil, etc. The eggs are laid in flat masses on the under side of leaves.

Photograph Courtesy U. S. Department of Agriculture

ONE OF THE SPHINX MOTHS, SHOWING HOW THOROUGHLY IT BLENDS WITH ITS SURROUNDINGS

When moths alight they, as a rule, fold their somber-hued forewings over their brighter underwings, and the former frequently so merge into the color and apparent texture of their environment as to escape the sharp eyes of their foes. This is known as "protective coloration" in biology, but armies call it "camouflage" in war.

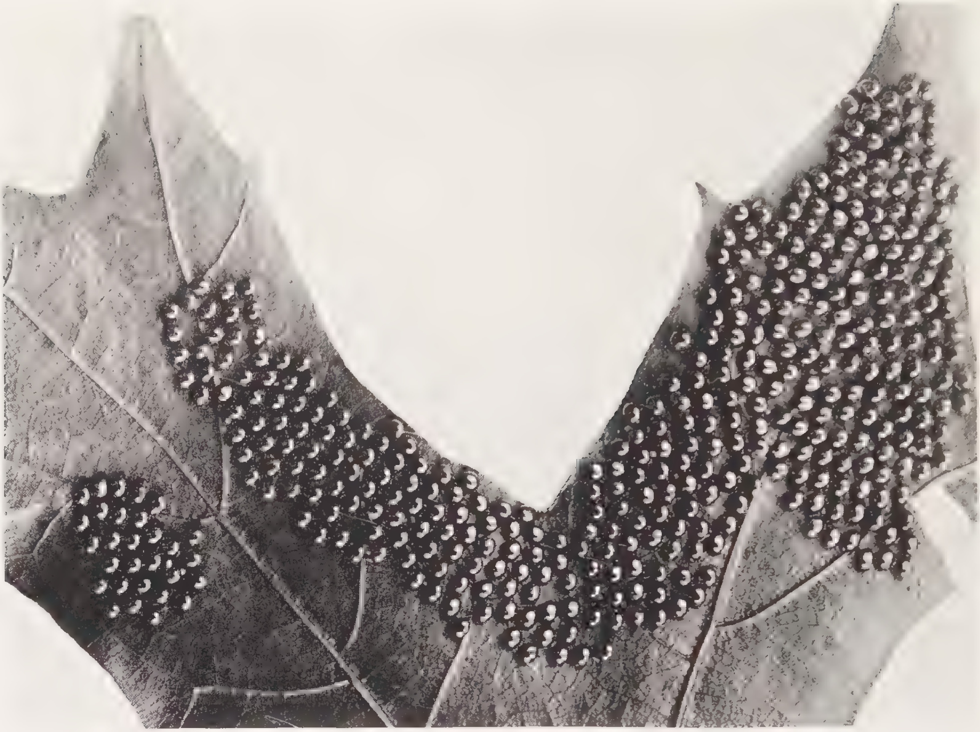
Arctia americana Harr. (Plate XIII, figure 18).—This species occurs in Canada, New England, and northern New York, the caterpillars much resembling those of the Ranchman's Tiger-moth. It is closely allied to its European representative, *Arctia caja* of Linnæus.

Adelocephala isias Bdv. (Plate XIV, figure 1).—This species is found in northern Mexico and southern Texas. The food plant of its caterpillar is the mesquite.

White-lined Syssphinx (*Adelocephala albolineata* G. & R.—also known as *Syssphinx albolineata.* Plate XIV, figure 2).—The White-lined Syssphinx is a native of Mexico and Central America, which is occasionally encountered in the region immediately north of the Rio Grande.

Honey-locust Moth (*Adelocephala bicolor* Harr. Plate XIV, figure 3).—The Honey-locust Moth has a range that embraces the area from the Great Lakes southward to Georgia and Kansas. Its caterpillars find the honey-locust and the Kentucky coffeetree especially to their taste. They are green, with silver and red thornlike horns.

Royal Walnut-moth (*Citheronia regalis* Fabr. Plate XIV, figure 4).—The Royal Walnut-moth is one of the most attractive of our larger scaly wings. Its caterpillar, on the



Photograph Courtesy U. S. Department of Agriculture

EGGS OF THE ORANGE-STRIPED OAK-WORM MOTH ON AN OAK LEAF

The species of moth that laid these eggs is shown in figure 6 on Color Plate XIV. Some moths lay only one egg to a leaf or even to an entire bush, while others lay great masses of them. In some cases they lay more than their entire body weight of eggs in a few days.

other hand, wears such an aspect that it has been called the "hickory horn devil" (see illustration, page 84). In the mature caterpillar these horns are reddish, tipped with black. Forbidding as they appear to be, they are quite harmless, as is their owner. These caterpillars feed on the foliage of such trees as walnut, hickory, butternut, ash, persimmon, sweetgum, and sumac. This moth is not uncommon in the Atlantic States.

Rosy Maple-moth (*Anisota rubicunda* Fabr. Plate XIV, figures 5 and 7).—The Rosy Maple-moth ranges from Canada to the Carolinas and westward to Kansas. Its striped caterpillar is a pest of silver maple trees. One scientific observer reports that this moth, once abundant in the Pittsburgh region, is now very scarce there, and attributes its disappearance to a group of adverse conditions, including odors from natural gas wells, flames from many chimneys which attract and destroy millions of adult insects, and the abundance of English sparrows.

Orange-striped Oak-worm Moth (*Anisota senatoria* A. & S. Plate XIV, figure 6).—The Orange-striped Oak-worm Moth is one of five species of its genus found in the United States. It is an Eastern species, closely related alike to the Stigma Moth and the Virginian Anisota. The hard, striped, horny larvæ are so stiff that they can be picked up and held by the tail.

Imperial Moth (*Eacles imperialis* Dru.—also known as *Basilona imperialis.* Plate XIV, figure 8).—The Imperial Moth has a rather wide range, and its caterpillars feed upon such a large variety of trees that they find relished pastures wherever they go. Like the Royal Walnut-moth, it has a wing-spread of five inches. The caterpillars of both of these species burrow into the ground to pupate, spending the winter as rough, brown, naked chrysalids.

Heiligbrodt's Syssphinx (*Adelocephala heiligbrodti* Harv.—also known as *Syssphinx heiligbrodti.* Plate XIV, figure 9).—This species is found in some sections of the Southwest, particularly in Arizona. Its caterpillars feed on greasewood bushes.

Stigma Moth (*Anisota stigma* Fabr. Plate XIV, figures 10 and 11).—The Stigma Moth's range extends from Canada to the Carolinas and westward to the Rocky Mountains. Its caterpillars feed upon various species of oak, principally the white oaks, whereas *A. senatoria* favors the black and red oaks.

Mendocino Silk-moth (*Saturnia mendocino* Behr. Plate XV, figure 1).—The Mendocino Silk-moth is found mainly in northern California. Its caterpillars feed upon manzanita.

Pamina Moth (*Hyperchiria pamina* Neum.—also known as *Automeris pamina*. Plate XV, figure 2).—This moth is found in Arizona. It is closely related to the more familiar Io Moth (see figures 8 and 9). Its pastures have been devastated by sheep herders and it is now extremely rare, if not extinct.

Range Caterpillar Moth (*Hemileuca oliviae* Ckll. Plate XV, figure 3).—This is another of the many species of tropical moths which is sparsely found along the southern borders of our Southwest. The caterpillars feed on grass and may destroy miles of grazing land, so that cattle starve.

Luna Moth (*Actias luna* L. Plate XV, figure 4).—The Luna Moth is found from Canada to Florida, and thence westward to Texas and Mexico. It is noted for its delicate green tinting and exquisite wing symmetry. The caterpillars feed on hickory, walnut, and other forest trees and pupate in thin, but compact, cocoons made of silk and leaves, on the ground.

Photograph Courtesy U. S. Department of Agriculture

THE MOTH OF ONE OF THE WOOLLY BEAR TRIBE IS ATTACKED BY A SPINED TREE-BUG

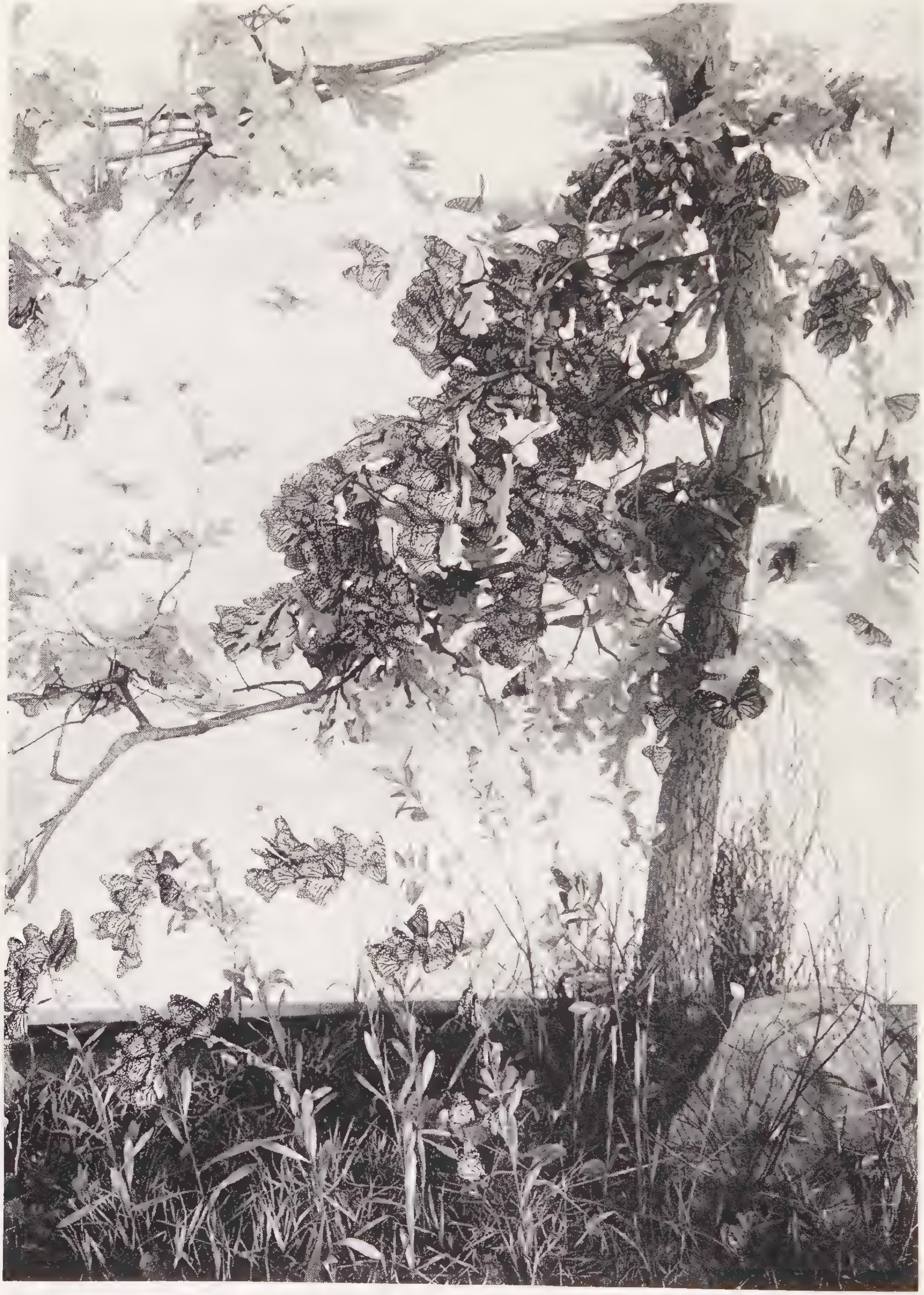
In the insect world "every individual's hand is against every other's," and between the parasitic gnats and mites that lay their eggs on the bodies of the caterpillars and the hundreds of insects, birds, and other foes which prey upon the adults, the Lepidopters have a perilous existence at best.

Buck-moth (*Hemileuca maia* Dru. Plate XV, figure 5).—The Buck-moth is a day flyer and wanders abroad in the mellow and warm noondays of the autumn, when the leaves are falling. It frequents the oak and other plants, where it deposits its eggs in clusters. The range of the Buck-moth extends from Nova Scotia to Florida and westward to Kansas. The black, spiny caterpillars feed together in companies until large, following each other in single file down the stems.

Pandora Moth (*Coloradia pandora* Blake. Plate XV, figure 6).—The Pandora Moth is a resident of the mountains of the West from Montana and Washington southward to Mexico. The larvæ are found on pine trees and are considered a great delicacy by the Indians, who make a, to us, disgusting soup of their bodies.

Pseudohazis eglanterina Bdv. (Plate XV, figure 7).—This species occupies the Rocky Mountain area and is characteristic of the country of open timber. It is largely a day flyer, darting about through the woods without apparent object. The adults take no food, the mouth parts being aborted. The larvæ feed on wild rose and other bushes.

Io Moth (*Hyperchiria io* Fabr.—also known as *Automeris io*. Plate XV, figures 8 and 9).—The fair Io Moth ranges from Canada to Florida and westward to Texas and Mexico. It has a versatile taste, so that its caterpillars find "skittles and beer" in a large number of species of trees and shrubs, low plants, and even clover. The caterpillars, with their clusters of branching spines, might be called the "curly poodles" of the insect world. The spines



Photograph Courtesy American Museum of Natural History

A THOUSAND MIGRATORY MONARCH BUTTERFLIES IN ONE GROUP

In early autumn Monarch butterflies, *Anosia plexippus* (see Color Plate IX, figure 12), assemble in great swarms in the northeastern section of the United States. This exhibit is in the halls of the American Museum of Natural History.

Photograph by Keystone

REELING SILK IN JAPAN

While the silk of commerce is made from cocoons whose chrysalids have first been killed by heat, the fine old silks of rarer sheen in China were usually woven from strands reeled from live cocoons (see text, page 97).

are covered with stings, which produce a sensation like nettle when coming in contact with the back of the hand or arm.

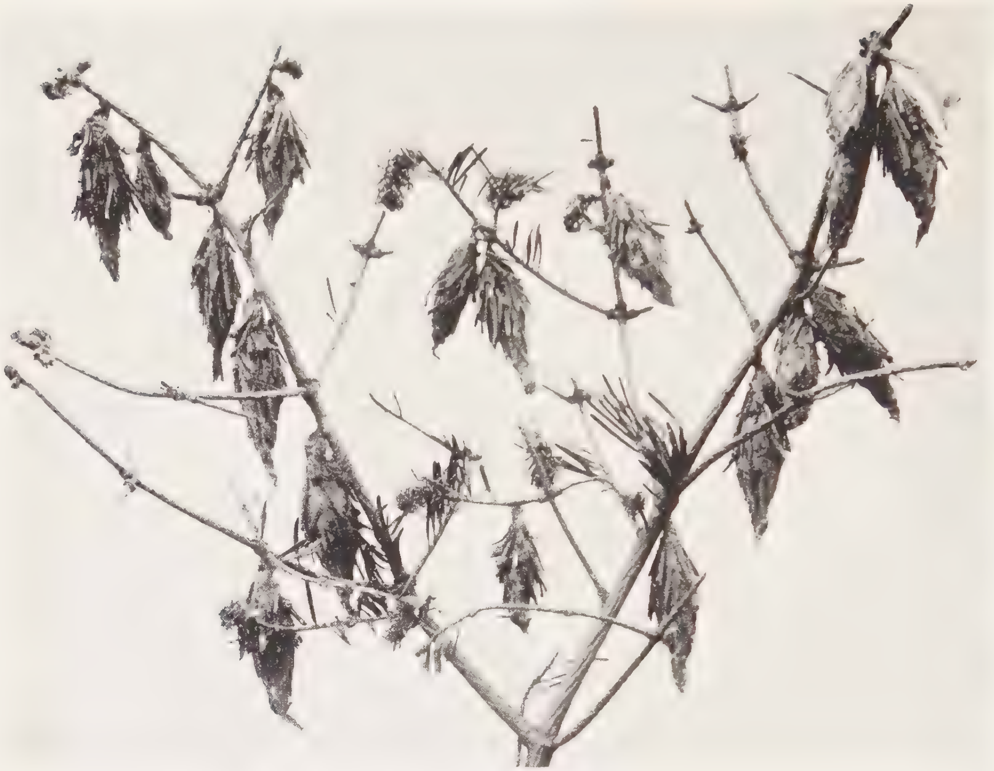
Hemileuca electra Wright (Plate XVI, figure 1).—This is a relative of the Buck-moth previously described (see Plate XV, figure 5). It is found in southern California.

Ailanthus Silk-moth (*Samia cynthia* Dru.—also known as *Philosamia cynthia.* Plate XVI, figure 2).—The Ailanthus Silk-moth is an immigrant to America. It was imported from eastern Asia and became thoroughly adapted to the eastern seaboard region of the United States. Its importation was for the purpose of founding a silk industry in the United States; but, although it is possible to make a good grade of coarse silk from it by process of carding, no profitable method of reeling the cocoons has been found, and therefore its importation has served no useful purpose. It feeds on the imported ailanthus tree and is a delight to every embryo naturalist.

Agapema anona Ottol. (Plate XVI, figure 3).—This species is found in Mexico and rarely in Arizona. It is a pretty species, but little is known of its habits.

Tricolor Buck-moth (*Hemileuca tricolor* Pack. Plate XVI, figure 4).—Arizona and New Mexico constitute the range of the Tricolor Buck-moth in the United States. Like most of their relatives, its caterpillars feed on the foliage of greasewood.

Polyphemus Moth (*Telea polyphemus* Cram. Plate XVI, figure 5).—This species is widely distributed over the United States and feeds upon a large number of trees. Fruitless efforts



Photograph Courtesy U. S. Department of Agriculture

WOOD-TRIMMED COCOONS OF THE PSYCHE MOTH, COMMONLY CALLED THE BAGWORM

The caterpillar of this moth makes a shell of silk and twigs to protect its tender body, only the head and forelegs remaining exposed. When the time to pupate arrives, the larva merely attaches its house (now a cocoon) securely to a branch, and backs into it and sheds to become a pupa (see text, page 93).

have been made to reel the silk it spins. The green worms are plaited like an accordion and studded with little red buttons.

Nevada Buck-moth (*Hemileuca nevadensis* Stretch. Plate XVI, figure 6).—This species resembles *H. maia* so much that some authorities class it as only a variety of the latter. Its range extends from the Rocky Mountains to the Pacific.

Rothschildia jorulla West. (Plate XVI, figure 7).—This moth occurs in Arizona, but is more common in Mexico. The genus to which it belongs is distinctly a neotropical one. These large moths with clear windows in their wings are very striking, being American representatives of the famed Atlas Moth of the East.

Spice-bush Silk-moth (*Callosamia promethea* Dru. Plate XVI, figure 8).—The Spicebush Silk-moth is found in the entire eastern part of the United States. The spicebush and sassafras are its favorite food plants. In pupating the larvæ usually rolls a leaf, tying it with silk, and then spins his cocoon therein, fastening the cocoon to the twig by a band of silk along the leaf stem. Though the fiber of the silk this species makes is rather tough, it is not spun with sufficient system by the present methods to make it available for use, either through carding or reeling.

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AFIELD WITH THE SPIDERS

By Henry E. Ewing

August, 1933

August 1933.

AFIELD WITH THE SPIDERS

Web Hunting in the Marshlands and Woodlands and Along the Lanes

By Henry E. Ewing

Entomologist, United States Department of Agriculture

FOR the spider enthusiast sojourning in the country, whether in the United States or in any other land of temperate climate, the dawn of a late midsummer day in a marsh meadow holds promise of delight. It is spider season, the time when the fairy spinners are to be observed at their best, when small, dainty webs, usually overlooked, stand out in perfect design against the green of leaf and grass, the filmy silk glistening with dew.

Webs, webs everywhere—hundreds of them, thousands of them—billow a gossamer sea in the morning light!

There are funnel webs, sheet webs, hammock webs, webs of indescribable shapes, and, finest of all, near the edge of the woods, the beautiful orb webs, bejeweled in their radiant symmetry.

Spiders are marvelous spinners. From the many microscopic spigots at the tips of their heavy abdomens they conjure several kinds of silk with which to construct webs of exquisite design and beauty. They make snares for their prey, sacs for their eggs, shelters for protection from enemies, draglines for security in movement, balloons for navigating the skies, and many other things for service in their varied and romantic lives.

FAMILY STYLES IN WEBS

Although the silken webs are of many different designs, the finery of the individual spider does not change with the passing seasons. Each species has its own style of web, to which all its members adhere so long as environment remains unaltered by geologic progress.

Students believe the first web, a simple tube, evolved from the draglines used by the spider in going in and out of a hole in the ground, its first retreat. These threads of silk finally lined the nest and radiated from the entrance. Striking against the lines, victims would be detected and seized by the watchful spider.

By extending the sheet about the entrance to the tube and bringing the latter out of the ground, the spider developed the funnel web. The axis of the web was shifted in the course of this change until the tube of the funnel became almost horizontal, and later the lower part was expanded into a net. These changes give us the typical funnel web, such as is spun by the common grass spider, *Agelena naevia* (see page 183).

Inside the tube of the funnel, especially when this tube leads backward among tangled blades of grasses, the spider still has protection from its enemies. The placing of the web above the ground and the expansion of the lower part of it into a sheet increased its efficiency as an insect snare.

INCREASING THE INSECT CATCH

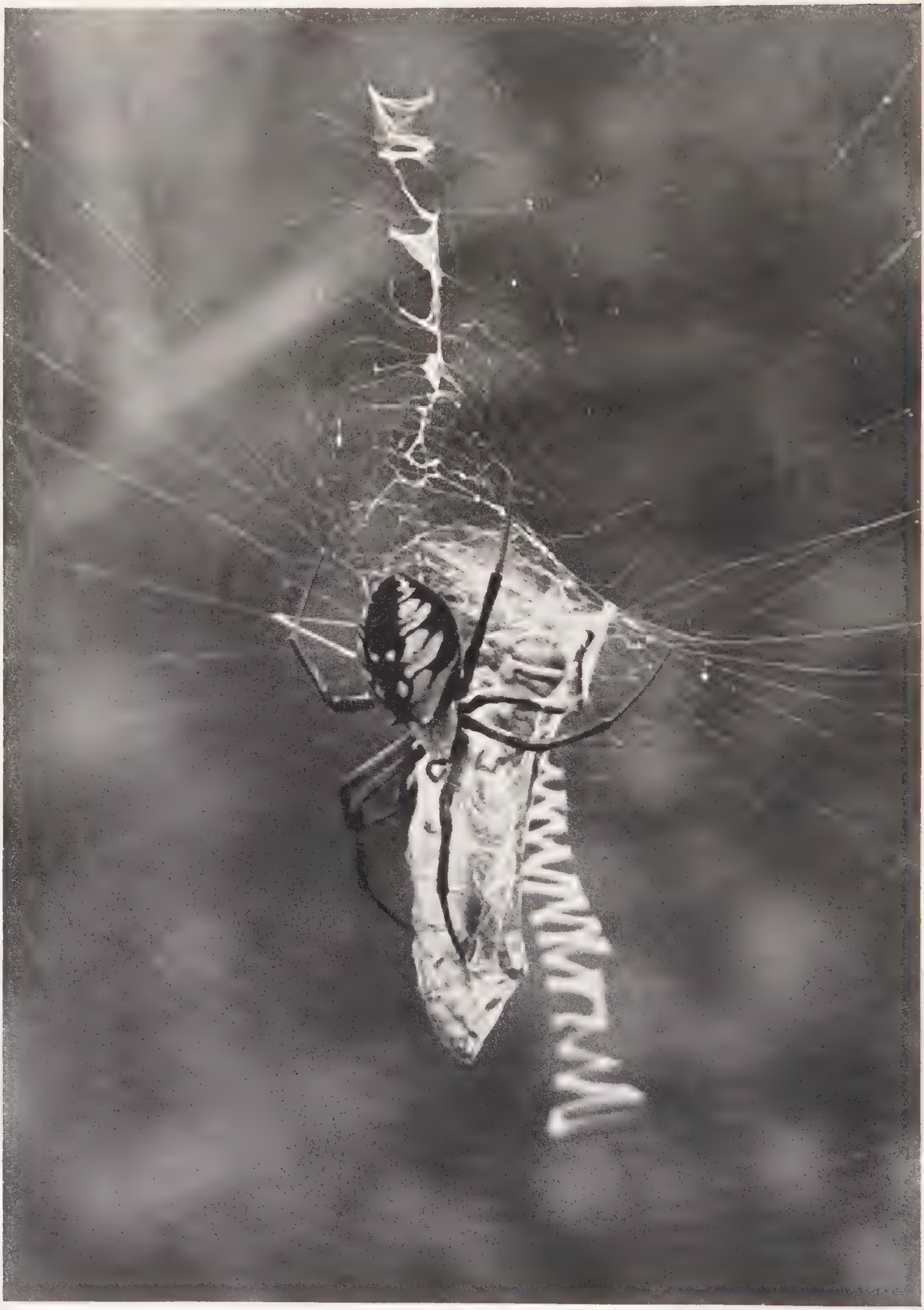
The tube, which leads away from the sheet part of a funnel web, becomes an inconvenience when webs are placed in exposed positions above the ground; hence the sheet-web weavers leave it out. By spinning the sheet in exposed positions, they are able to increase their catch of flying insects. Such closely woven sheets, however, offer dangerous resistance to the wind.

Spiders commonly modify sheet webs in two ways: They may bring the sides of the sheet upward to produce a hammock or bowl (see page 183), or downward to form a dome (see page 186).

The advantage of the bowl type is easily noted by observing our bowl and doily spider, *Linyphia communis*. It places its hammocklike web well below the tops of small shrubs or large herbaceous plants and directly under the favorite feeding places of such insects as plant lice and leaf-hoppers. Naturally every disturbance of the twigs and leaves shakes a shower of titbits into the snare.

The dome-shaped web is better suited for catching insects rising from the ground in flight, as many do about dusk or in the morning.

Irregular net webs, haphazard tangles of threads of all lengths, are spun by that annoyer of housewives in all temperate climates, the common house spider, *Theridion*



Photograph by Lynwood M. Chace

THE GOLDEN GARDEN SPIDER WEAVES A SHROUD

An unwary grasshopper has stepped into the perilous parlor of *Miranda aurantia* (see Color Plate V, lower left), and his hostess quickly spins a winding sheet about him. Although still alive, the victim cannot move a leg.

Photograph by Clifton Adams

HASHIME MURAYAMA PAINTS THE FRONTISPIECE FOR THE SPIDER COLOR SERIES

Working with an array of scientific instruments, a versatile artist of the NATIONAL GEOGRAPHIC MAGAZINE staff records in water colors the most minute details in the appearance of his subjects. He studied live specimens, kept in the jars at the right, and fed flies and other common insects.

tepidariorum (see Color Plate IV), and by many other species. Once considered primitive, such webs now are regarded as degenerate. They probably represent an evolution from the sheet type, altered to decrease resistance to the wind and to facilitate mending. As fly-traps, they are effective and, in addition, usually serve well for rearing the brood of spiderlings.

Like human fishermen, many spider species have found that a plane net of two dimensions is not only economical of weight and materials but ideal for landing a catch. The orb web, built on this principle, may be put in exposed places, where prey is most plentiful, since with its open construction it offers little resistance to the wind.

Suspended from a framework of stout base lines and carefully spaced to permit freedom of movement in spinning, its threads form a wheellike design of maximum strength with a minimum of material. The spider sits at the hub, ready instantly to detect a snared victim and pounce upon it. In the net-snare method of catching prey the orb web is the spider's last word. Few, if any, other animals, human or subhuman, have equaled it.

Although the most symmetrical web ever made by a spider is not really perfect, according to human standards, scientists marvel at the accuracy with which angles and distances are "measured."

SPIDER "GEOMETRY" IS INGENIOUS

The spider starts her geometrical web with perimeter lines connecting objects around a space large enough for her purpose. From these lines she suspends a few threads which converge at the center of the future web. Now begins the process of spacing the radii. She attaches the end of a new radius at the center and runs along a spoke already laid down, spinning out the silk for the new one as she goes. When she reaches the perimeter line, she takes a fixed number of steps along it and attaches the new thread. This process is repeated until all the desired radii are in place.

If the foundation lines should chance to form a wheel rim accurately circular, the distances between spokes would be equal;

but, since the perimeter is usually an irregular quadrangle and never a circle, the spacing varies somewhat.

The spiral turns of silk, which complete the net, are more accurately spaced than the radii, since the spinner lays down each new turn with her foreleg touching the last one. Thus the length of the forelegs and the size of the spider determine these distances.

"Scout stepping" and use of the "leg ruler" are instinctive in spiders. Even when isolated from its kind from the moment of its birth, a spiderling will produce exactly the same web design as its mother and in exactly the same manner.

Spiders constitute a large clan of some 25,000 described species. Although most abundant and diversified in the Tropics, they range far into the Arctic regions, and are found almost everywhere that earthly conditions will sustain life.

THE WORLD'S LOFTIEST DWELLERS

Far up on Mount Everest, above the highest plant life, at an elevation of 22,000 feet, spiders have been found living among the wind- and snow-swept rocks. Thus they are the loftiest permanent inhabitants of the earth.

Some spiders, such as the trapdoor makers, occupy only a restricted area; while others, such as our common house spider, *Theridion tepidariorum,* are found in many lands and all the continents.

The largest spiders are the American tarantulas, and of these the South American species, *Theraphosa leblondi,* with a body three and a half inches long, is the giant. Its bulk is more than 100,000 times that of the smallest spider known.

In Central America is found its closest rival in size, *Sericopelma communis* (see Color Plate II). South America produces both the Brobdingnagians and the Lilliputians of spiders, one of the latter, *Ogulnius obtectus,* being barely one-twenty-fifth of an inch in length.

Far from typifying masculine strength, aggressiveness, and dominance, the males of many spider species are much smaller than the females, and are such poor spinners that it is difficult for them to procure their own food. Some of them either use snares previously built by females or literally live on the "crumbs from the tables" of their mates. Males, however, are inclined to be more active than females and may be of roving disposition.

In a few species, such as the brush-legged spider (see Color Plate VI, B), the male, less than one-hundredth the size of the female, is little more than a fertilizing mechanism to insure the perpetuity of the species.

NEW CLOTHES FOR OLD

To allow for the expansion of the soft parts of the body during growth, spiders periodically cast their skins (see Color Plate II), new coats and new claws replacing the old. When tarantulas are exhibited singly, in cages, the sudden appearance of a cast skin, seemingly intact, may cause astonishment on the part of a keeper, who takes it to be another spider. The old skin splits along the sides of the body just above the bases of the legs. The suture passes from one side to the other in front, but does not pass around the rear of the body. In an insect, the old skin usually splits down the middle of the back.

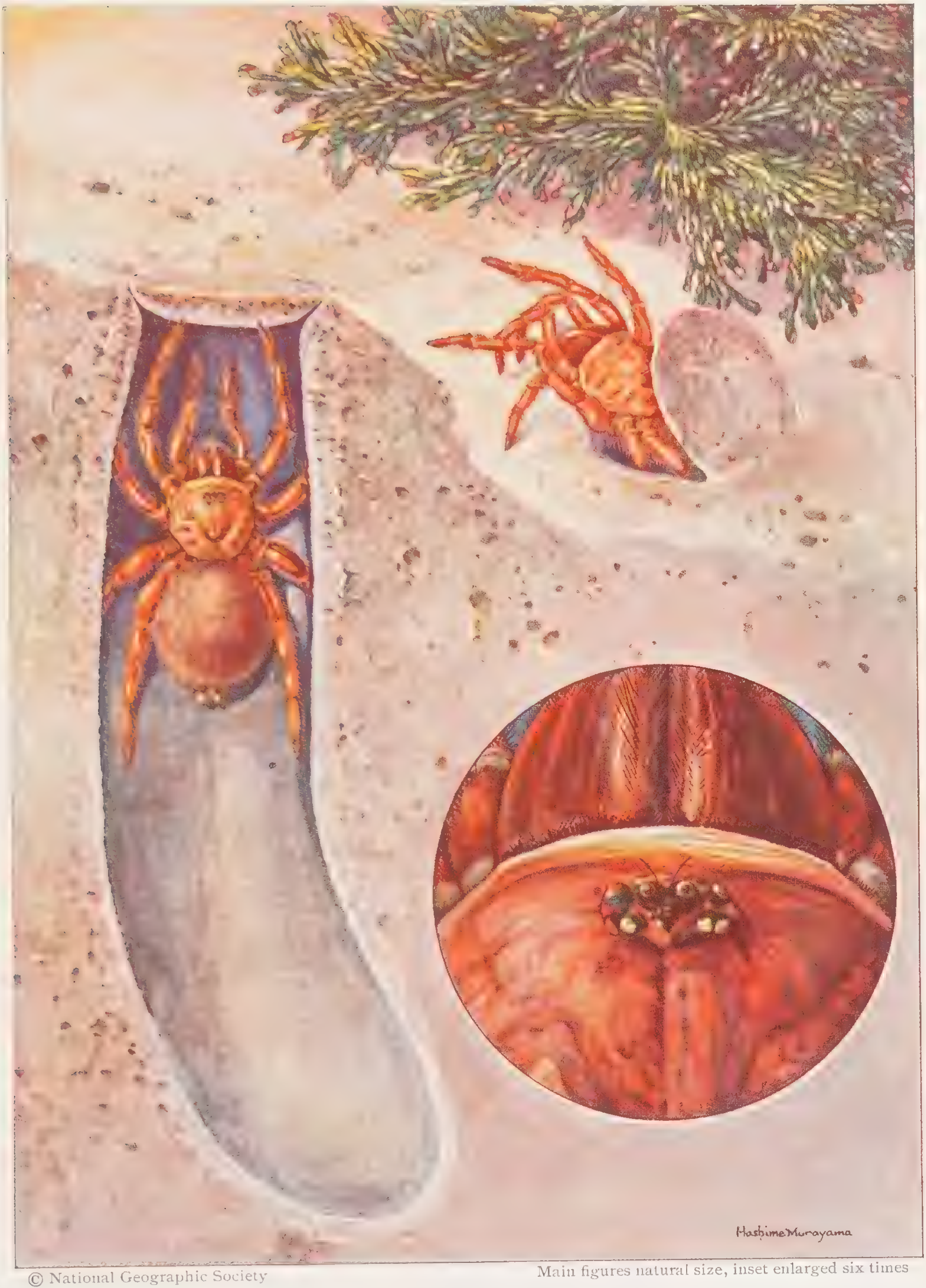
The spider does not, like the caterpillar, spin a cocoon about herself. How, then, does she place her egg mass in the silken sac? The problem puzzled me for years, until a common house spider solved it by a performance before my eyes.

First she spun a cone, or cap-shaped, base (see Color Plate IV). She did this by holding her weight with the first and second pairs of legs, rotating the structure with the third pair, and laying on the silk with the back pair.

After completing the base, she forced the egg mass out of the vulva (see Color Plate IV). The eggs, covered with a sticky substance, clung together in a ball, which she fixed in place by pushing it upward while she pulled the opposite margin of the silken base down and under it. This accomplished, she more leisurely completed the outline of the sac, thickened it by laying on much more silk, and finally finished it by tamping down the protruding loops with her mouth parts. The whole process of egg-laying and sac-making took about one hour.

SPIDER AVIATORS BUILD AIRSHIPS

Although wingless, spiders can take to the air and reach distant places. Nature has endowed them with the capacity of "balloon" building and given them such remarkable instincts for using these airships that few winged creatures can surpass their flying feats!



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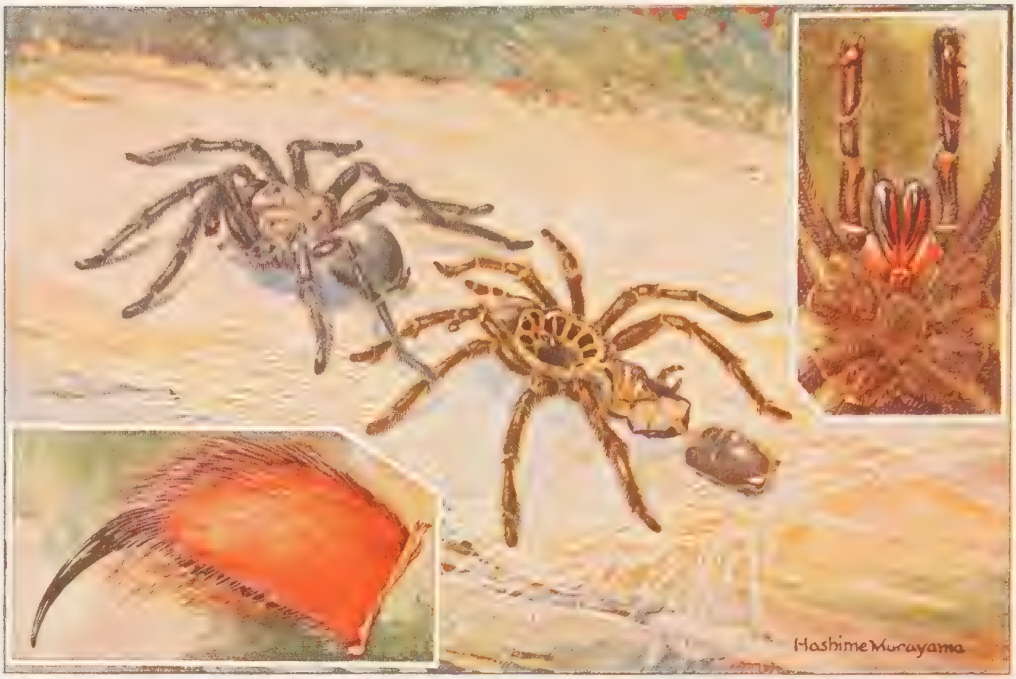
Main figures natural size, inset enlarged six times

ONE KIND OF SPIDER LIVES IN HER OWN CELLAR

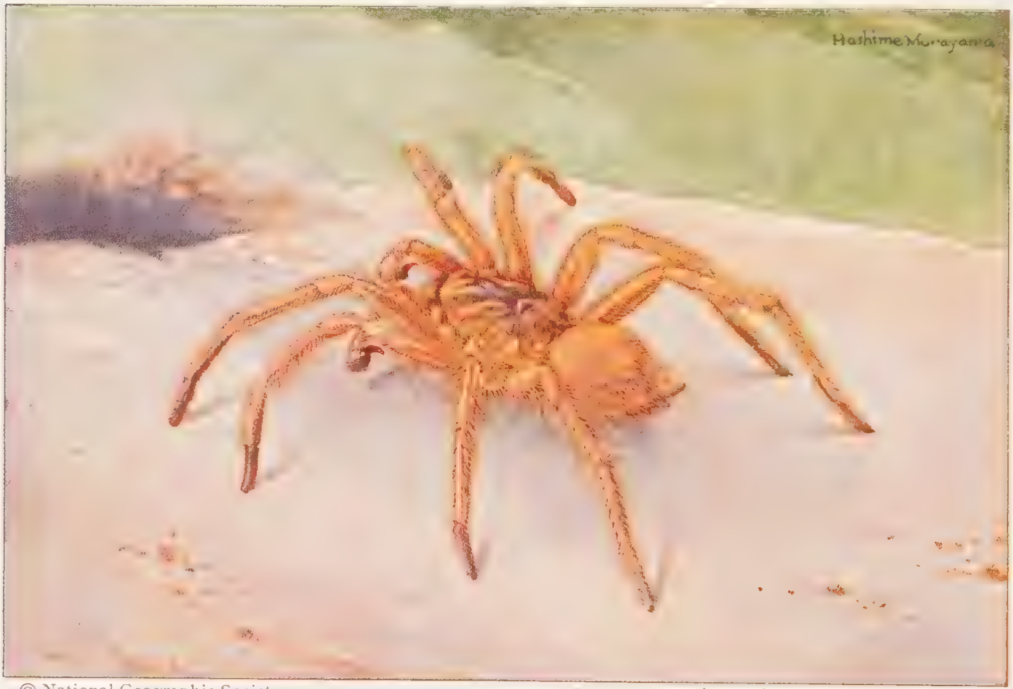
This trapdoor species, *Pachylomerus audouini*, common in South Atlantic States, closes her bottlelike basement home with a wafer-type lid, which she operates with her legs. Her California cousin, described in a separate article, makes a cork-type covering and opens it or holds it shut with her fangs and legs. The ocular turret of an eastern specimen is shown in the inset at the right.



Approximately one-half natural size

OUR COMMON WESTERN TARANTULA CRAWLS NEATLY OUT OF HIS SKIN

Though fearsome looking, with sharp fangs (lower inset) and large fuzzy body (upper inset), this adult male merits the friendship of his human neighbors in southwestern States, for he feeds on grasshoppers and roaches. The bite of the species is painful but not poisonous to man.



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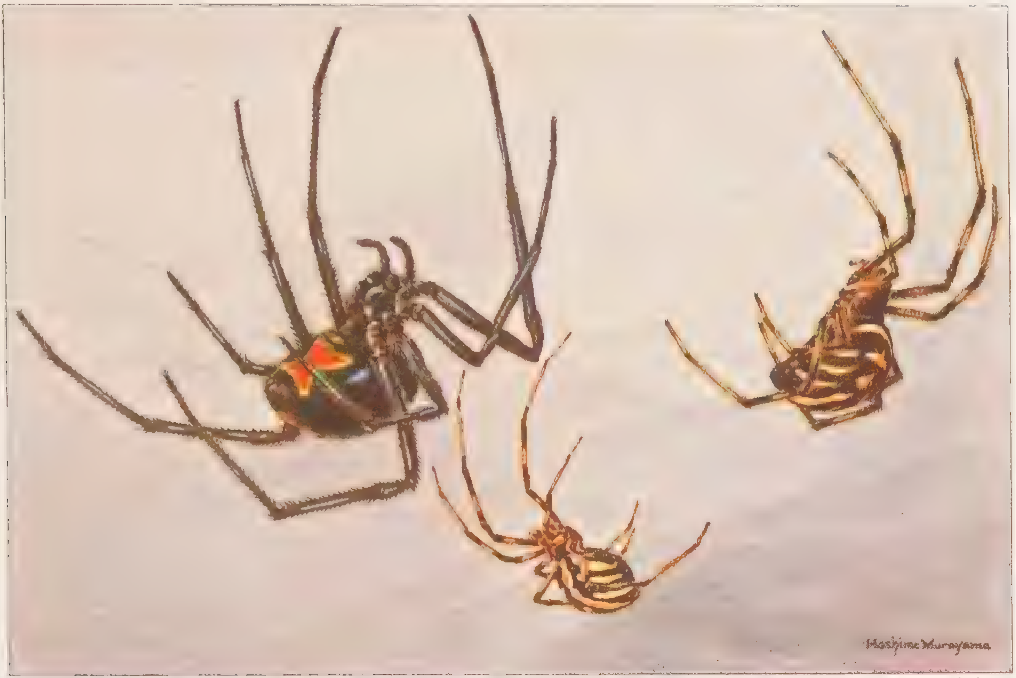
Approximately one-half natural size

MEMBERS OF ONLY ONE SPECIES EXCEED THIS GIANT IN SIZE

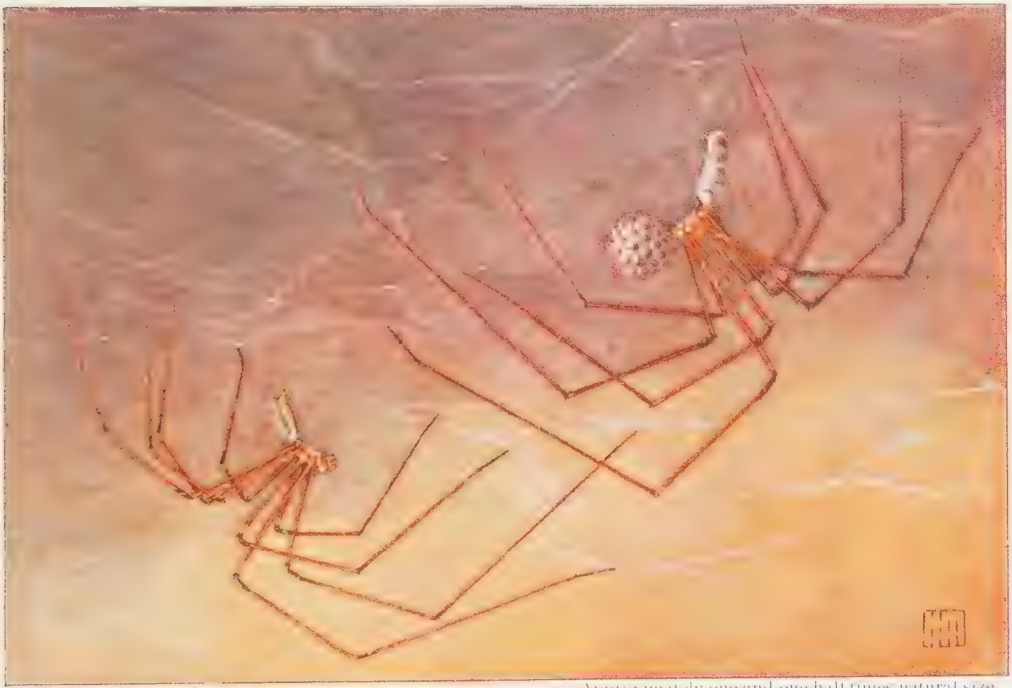
The Central American tarantula, *Sericopelma communis*, of which the specimen here shown is an adult male, catches and kills birds, but it is smaller than the *Theraphosa leblondi* of South America. Though extremely painful, its bite does not cause death.



Approximately three times natural size

BEWARE THE BLACK WIDOW, MOST VENOMOUS SPIDER IN THE UNITED STATES

Beautiful but dangerous, *Latrodectus mactans* should be shunned. The adult female (left) measures almost a half inch in length, twice as large as her mate (below). The daughter (right) until mature resembles the father. Rather common in the South, the species is rare in the North.



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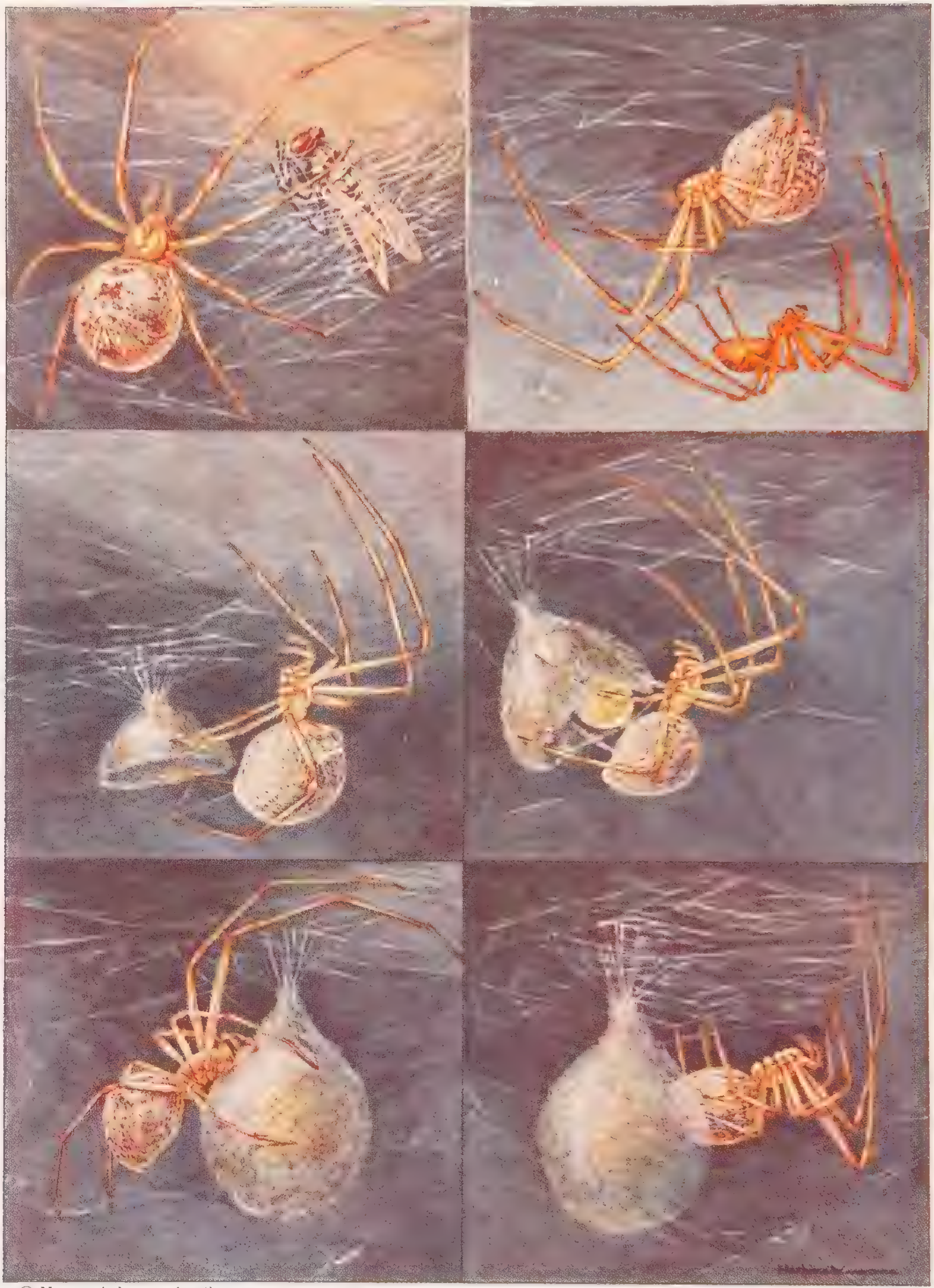
Approximately one and one-half times natural size

NOT DADDY LONGLEGS, BUT SPIDERS

Around back doors or in basements in the warmer countries, pairs of *Pholcus phalangioides* build their irregular webs. The female (right) carries her egg mass in her jaws and feeds little till the young are hatched. The mate, unlike males of other species, can take care of himself.

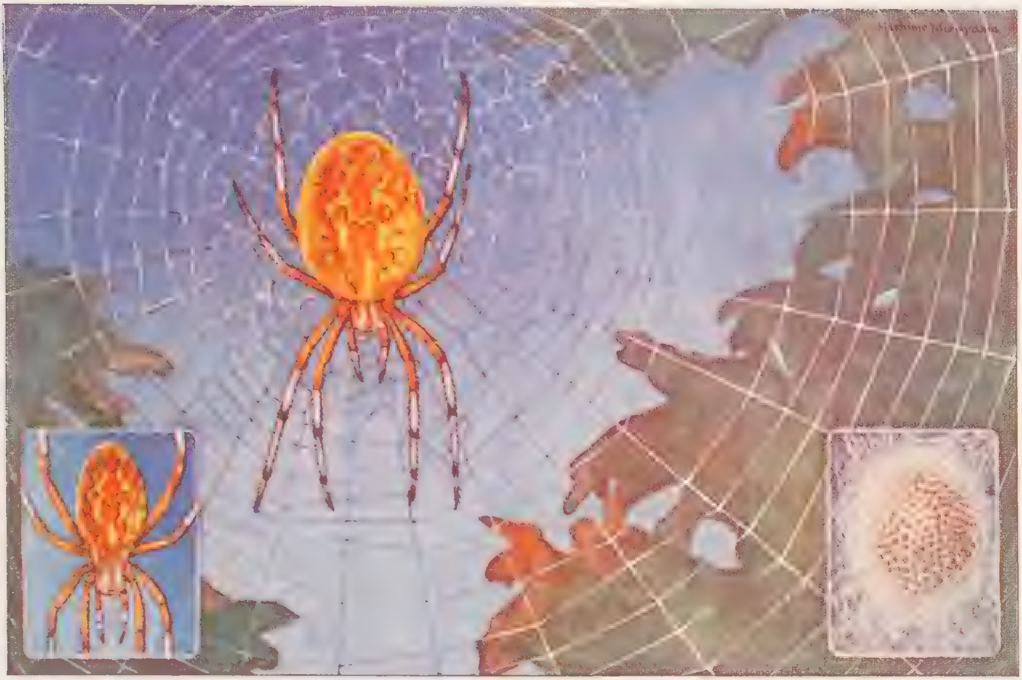


© National Geographic Society

Approximately three times natural size

OUR UNWANTED GUEST, THE HOUSE SPIDER, IS AN INTERESTING NUISANCE

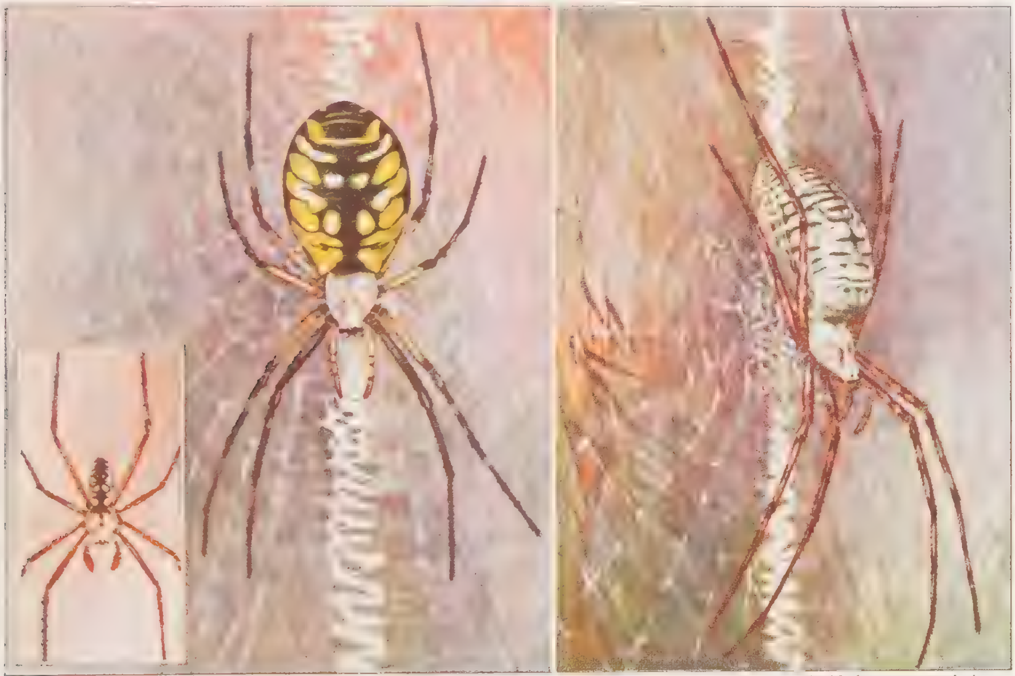
More than any other species, *Theridion tepidariorum* is responsible for the irregular, sticky, dust-catching cobweb; but its habits merit study. An adult female (upper left) obliged the artist by posing in the act of pouncing upon a trapped fly. Another, with her shiftless mate below her (upper right), spun some haphazard threads. A third fashioned a silken base (middle left), placed her egg mass within it (middle right), worked down the loose ends (lower left), and finally rested beside her finished cocoon (lower right).



Approximately one and one-half times natural size

HEAVY WITH EGGS, THE FALSE SHAMROCK CLINGS TO HER WEB

One of the showiest of spiders, *Araneus marmoreus*, may be seen in autumn throughout most of North America and in parts of Europe. The female, after laying, becomes much smaller (left inset). She encloses her egg mass in silk (right inset) and then dies.



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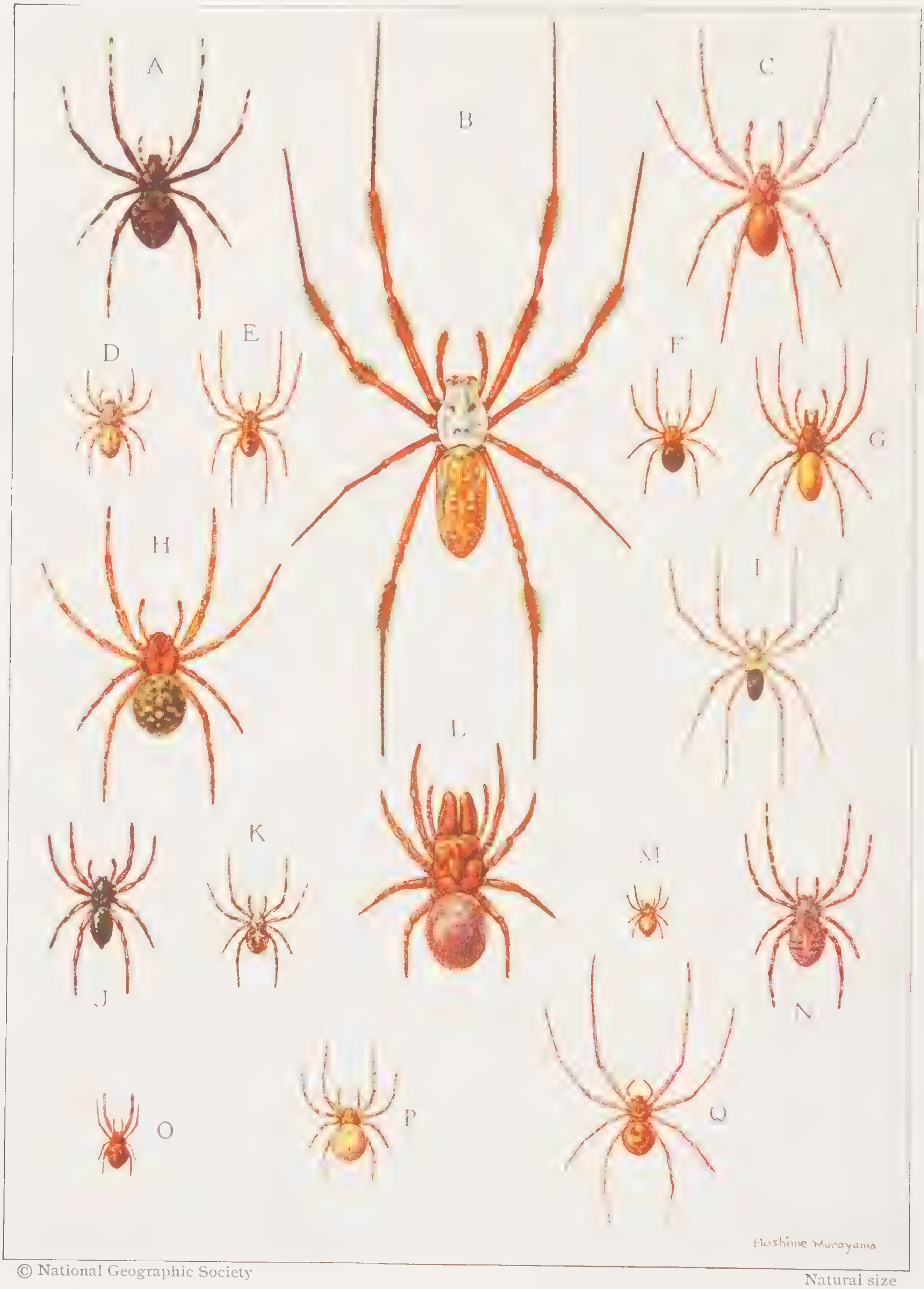
Approximately one and one-half times natural size

GOLDEN GARDEN SPIDERS: BANDED GARDEN SPIDER

The showy specimen at the left, an adult female, *Miranda aurantia*, weaves a large geometrical net over prize blossoms; but the flower enthusiast forgives her, since she eats plant lice. Her "husband" (inset) seems a puny dwarf. *Metargiope trifasciata* (right) is rarer than her cousin.



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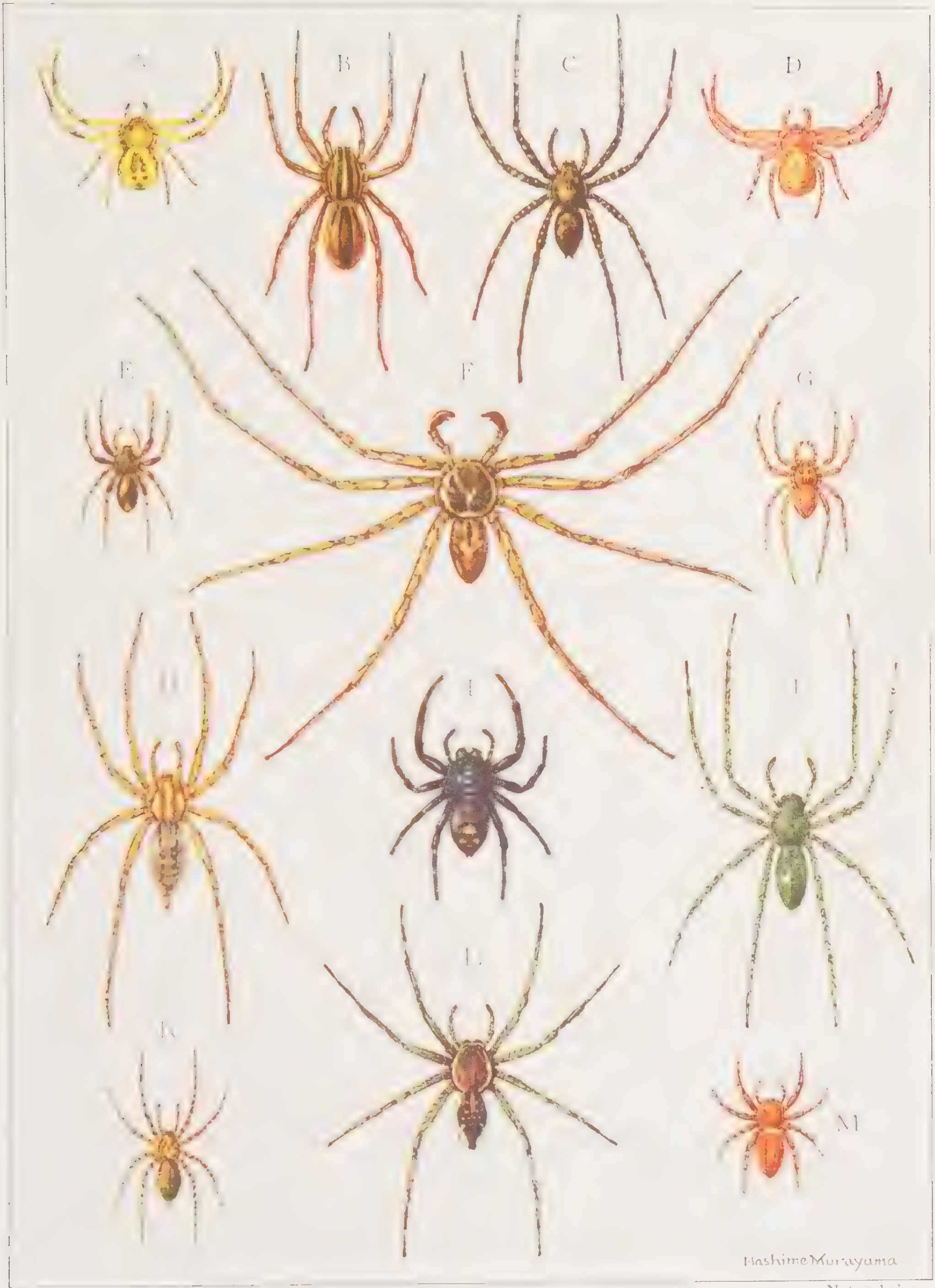
Natural size

FABRICS OF MANY DESIGNS COME FROM THESE ASSORTED SPINNERS' LOOMS

A, *Araneus benjaminus*, H, *Araneus trifolium*, K, *Araneus labyrintheus*, N, *Araneus vulgaris*, and P, *Araneus thaddeus*, make typical orb webs. B, *Nephila clavipes*, is a silk spider. C, *Filistata hibernalis*, D, *Amaurobius bennetti*, M, *Hyptiotes cavatus*, and O, *Uloborus americanus*, are hackled-band weavers. E, *Linyphia phrygiana*, spins a sheet, while F, *Steatoda borealis*, produces mere cobwebs, and L, *Atypus abbotii*, fashions a tube. G, *Dysdera crocata*, I, *Loxosceles rufescens*, and Q, *Scytodes longipes*, have six eyes. J, *Zelotes ater*, is a drassid, moss spider. See accompanying article.



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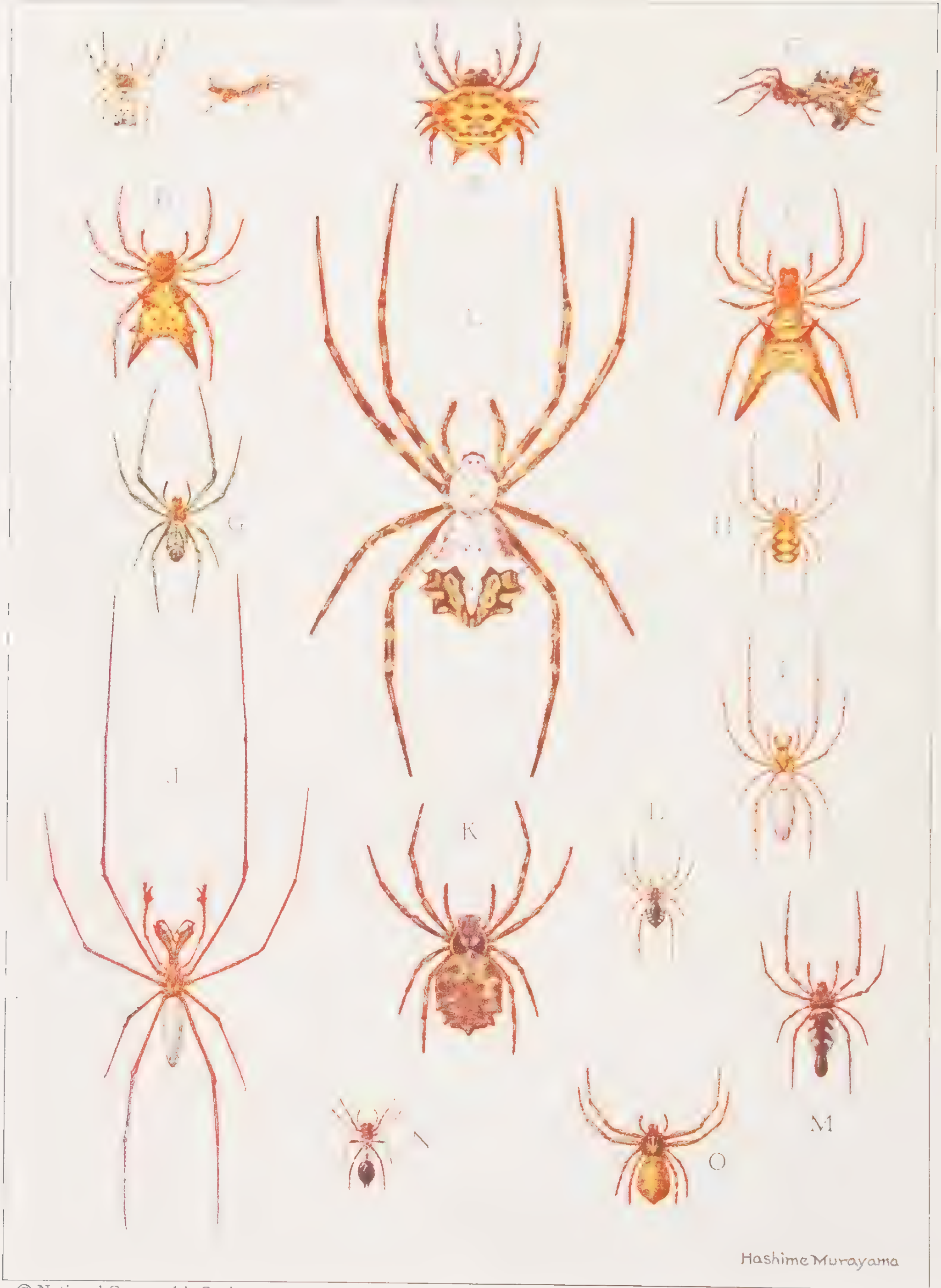
Natural size

MENAGERIE CHARACTERS AND ATHLETES PREDOMINATE IN THIS LOT

A, *Misumenoides aleatorius*, D, *Xysticus limbatus*, and F, *Heteropoda venatoria*, are crab spiders. B, *Lycosa punctulata*, is the wolf, and J, *Peucetia viridans*, the lynx. C, *Dolomedes urinator*, and L, *Dolomedes triton*, excel as divers; and I, *Phidippus audax*, M, *Phidippus clarus*, as acrobats (jumpers). "Brush-footed" describes E, *Castaneira descripta*, and "Wandering" G, *Anahita punctulata*. H, *Agelena naevia*, and K, *Coelotes fidelis*, fall into the group of funnel weavers. Descriptions appear in the accompanying article.



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Approximately one and one-half times natural size

PERFECTLY HARMLESS DESPITE THEIR FORMIDABLE APPEARANCE

A, *Micrathena reduviana*, B, *Gasteracantha cancriformis*, C, *Micrathena gracilis*, D, *Micrathena sagittata*, and F, *Micrathena obtusospina*, are spined spiders. E, *Argiope argentata*, is a garden spider. G, *Leucauge venusta*, and its relative M, *Leucauge lugens*, weave horizontal orb webs. H, *Teutana triangulosa*, contents itself with cobwebs. The spiny-jawed species are represented here by I, *Tetragnatha laboriosa*, and J, *Tetragnatha elongata*. Others on the page are a typical orb weaver, K, *Araneus stellatus;* a sheet-web weaver, L, *Linyphia communis;* a mimic, N, *Synemosyna formica;* and a crab spider, O, *Tmarus angulatus*. The accompanying article gives descriptions.

Spiders were navigating the skies just as they do to-day millions of years before man invented the gas-filled silk bag with which he first soared above the earth.

The spider's balloon, like man's, is of silk; but, much simpler, it needs no gas. When its filmy threads are let out they catch the upward currents of air, and thus carry away the tiny aviator. Some spiders, by taking advantage of trade winds, have floated out over oceans and reached islands hundreds of miles from any continental shore.

Spiders may balloon at any time of the year, but it is in October or November, when harvests have been gathered and the golden haze of Indian summer tinges upland and lowland, that the season is at its height for the flight of baby spiderlings. Breaking from the prison walls of their cocoons, they scatter quickly, as if impelled by wanderlust.

Each climbs to the top of some elevated object, and during the heat of the day lets out many filmy strands of silk. As these float upward and away they lift the spinner's abdomen. Then more silk is spun.

Out and out it goes, until finally the spiderling is seen clinging to his perch only by the tips of his legs, so strong is the pull of the silken balloon. Now a little more silk and away goes the aviator, over fields and meadows, over pastures and woodlands, to his future home.

THE ORIGIN OF THE TARANTELLA

Late in the Middle Ages southern Europeans became obsessed by an unreasoning and unreasonable fear of spiders. They dreaded particularly the European tarantula, a medium-sized wolf spider, *Lycosa tarantula,* the bite of which was supposed to cause dizziness and nausea, followed by depressing melancholy and eventually death.

Popular superstition held that only the "medical" choreographers could save *tarantati* (bitten persons). If only the right tune could be found, music and the dance would do the trick. The choreographers professed ability to select suitable music for any "patient."

Skipping and cavorting "with great vigor and variety of steps" made the patient perspire freely, and supposedly the deadly poison left the body with the perspiration. In the wild antics devised to shake off the dread tarantism originated a charming dance, the tarantella.

Superstition and quackery gave way slowly before scientific experiments that proved the tarantulas of Europe really rather harmless. But meanwhile the white settlers of America had come in contact with much larger and more ferocious-looking spiders. The American spiders would kill little snakes, or toads, or even birds. Naturally these fearsome creatures, though actually Aviculariidae, were called tarantulas and made the object of the same fears and superstitions that had held in Europe.

We know to-day that there is little justification for fear of our true tarantulas. One member of this group, however, the giant *Sericopelma communis* of Central America (see Color Plate II), appears to be an exception in regard to its venomous nature.

ONE VENOMOUS CLAN IS HEADED BY THE BLACK WIDOW

Although science has exploded most of the exaggerated fears of spiders in general, it has convicted as dangerously venomous one small group, the genus *Latrodectus,* found throughout most of the warmer countries of the world.

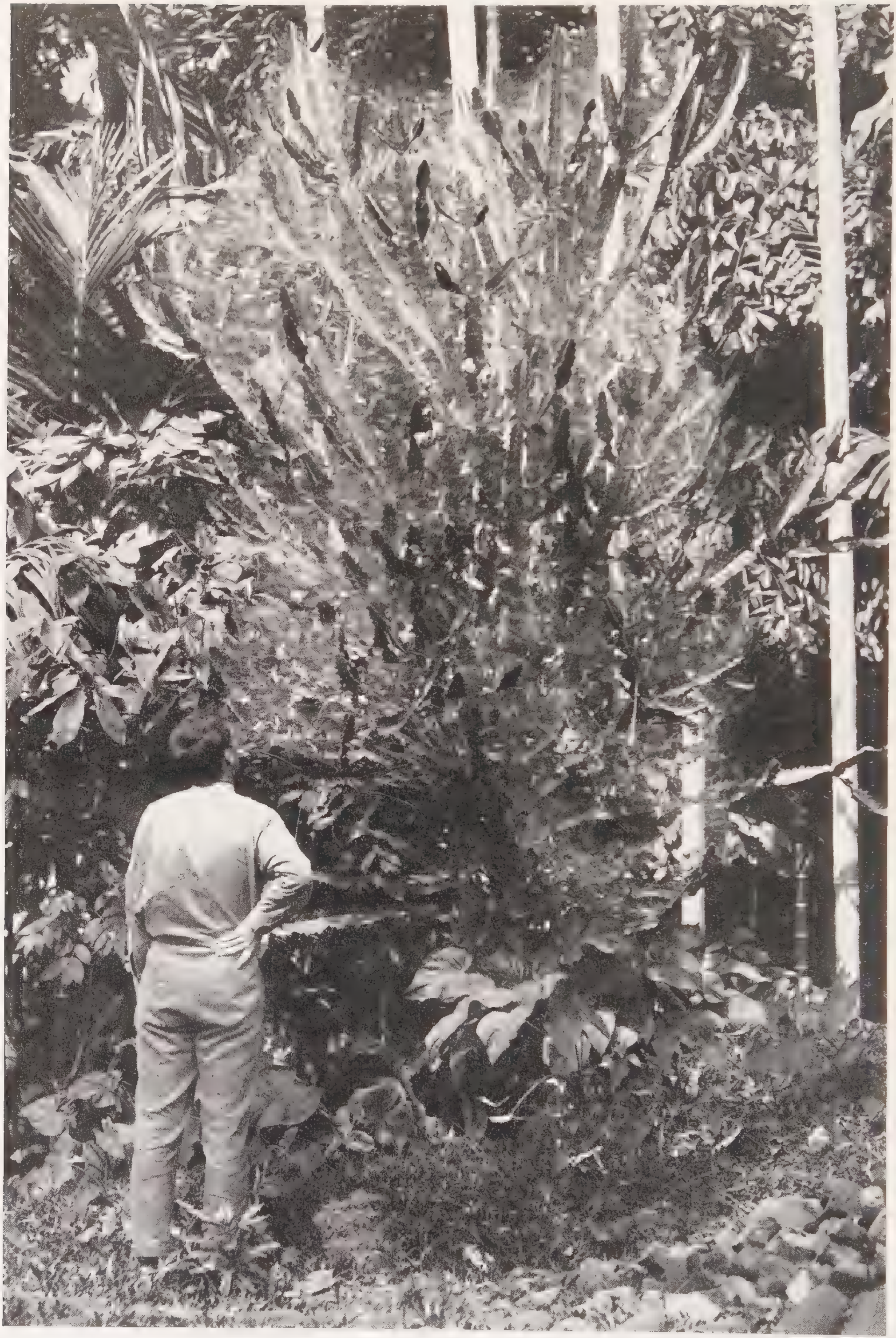
The best-known representative of the clan in the United States is the black widow, *Latrodectus mactans* (see Color Plate III), somewhat common in the South, rare in the North.

These spiders are rather closely related to the common house spider, *Theridion tepidariorum* (see Color Plate IV), belonging, as they do, to the same family, the Theridiidae; but they have greatly enlarged poison sacs, and the venom they inject is more potent than that of a rattlesnake!

Fatal cases affecting man are rare; yet numerous fatal cases of *Latrodectus* bite affecting domestic animals have been recorded recently in foreign countries.

Black widows occur in Nature under old logs, about the bases of tree trunks, under loose bark, and in other dark places near the ground. About human habitations they more commonly are found in stables, outhouses, and basements.

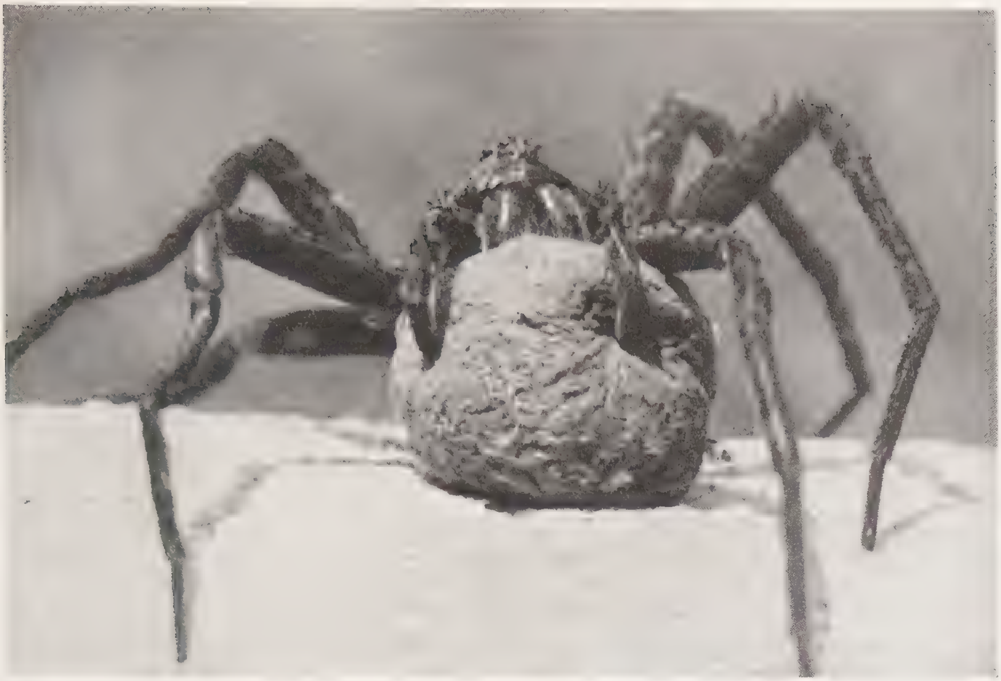
The bite of the female (the male is not known to bite man) is followed by a sharp pain. A small white spot soon appears surrounding each puncture point. Within half an hour aching pains arise in other parts of the body, frequently followed by cramped breathing. After a bitten patient is put to bed, some fever may develop, pains become intense, and delirium ensue.



Photograph courtesy U. S. Department of Agriculture

A CEREUS PLANT NEAR KANDY, CEYLON, SUPPORTS A SILKEN COÖPERATIVE APARTMENT

Community spiders, unlike most other species of the spinners, are gregarious and enjoy close association with their fellows. They spin their webs together, often completely covering a large shrub or even a tree.



Photograph by Lynwood M. Chace

MATERNAL INSTINCT IS STRONG AMONG THE SPIDERS

That precious sac—not for one moment will the mother part with it. Females of some species place their eggs on the webs and stand guard over them. Others constantly carry the silk-encased masses in their jaws or tied to the tips of the abdomens. This member of the Dolomedes clan holds her burden with her palpi.

Recovery is nearly always within two weeks (see illustration, page 179).

By careful inspection, premises usually may be cleared of this spider. Not only the live individuals, but also the round, whitish egg sacs, which are placed in the irregular web of the female, should be destroyed. Close screening tends to keep them out of basements.

SPIDER SILK FOR MAN'S USE

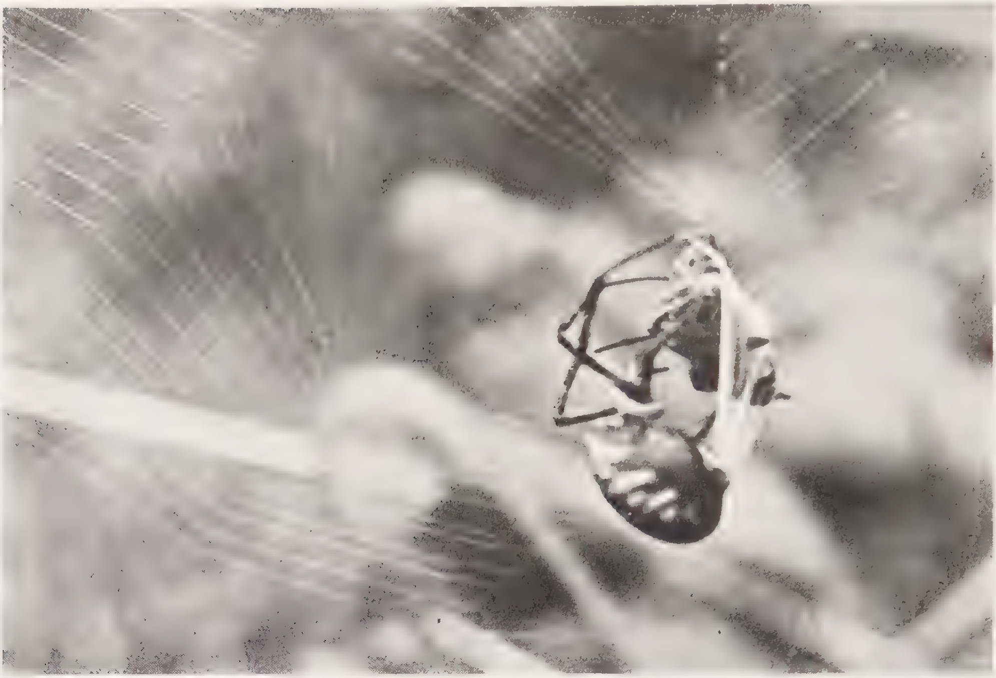
The possibility of the utilization of spider silk in the textile industry was investigated in France more than two centuries ago by Bon, a pioneer enthusiast, who collected a large number of spider cocoons, obtained a quantity of very fine gray silk from them, and made of it some daintily colored stockings and gloves. When he exhibited his product before the Academy of Sciences of Paris, that body was so much impressed that in 1710 it commissioned the entomologist Réaumur to investigate the possibilities of utilizing spider silk as a textile.

Réaumur began his inquiry with high hope and enthusiasm, but when he had finished it he was compelled to recognize certain insurmountable difficulties.

The spider silk was inferior to that of the silkworm; the so-called cocoons, in reality merely egg sacs, which only half of the spider population would produce, contained disappointingly little thread; and the spinners themselves were carnivorous, irritable, and belligerently opposed to crowding. It was almost impossible to provide them with enough food of the proper kind, and to isolate individuals so as to keep them from fighting.

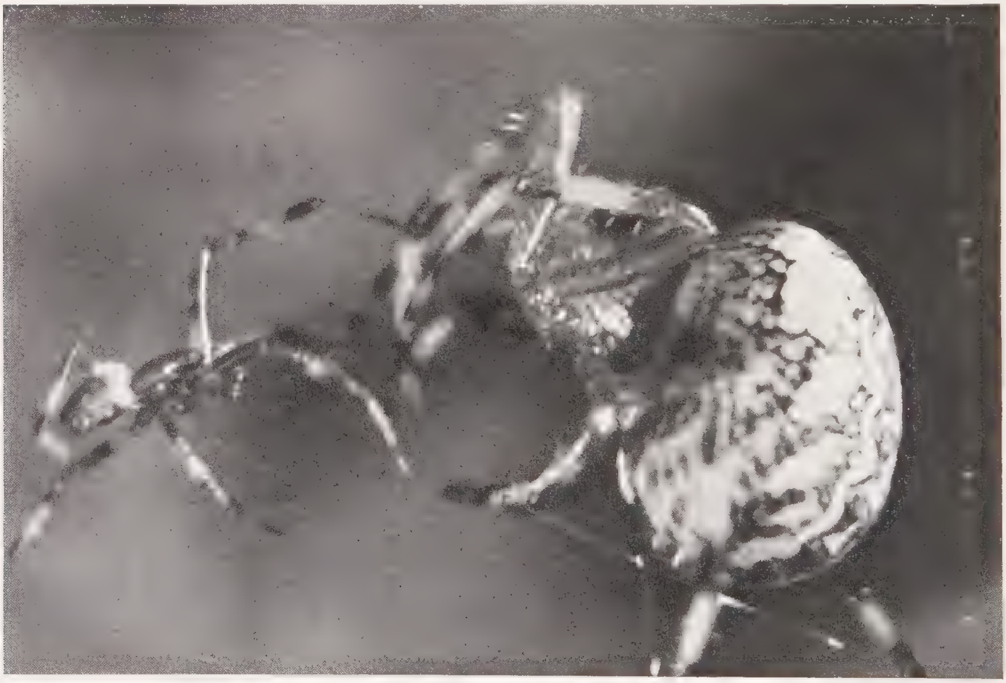
Since Réaumur, others have taken up the problem of finding a way to utilize spider silk. Professor Wilder, stationed in South Carolina as an Army surgeon during the Civil War, became interested in the spinning ability of our brush-legged spider, *Nephila clavipes* (see Color Plate VI, B), and made extensive investigations. He sought to obtain the thread, not from the cocoons, but directly from the abdomen of the spider.

Devices for reeling the threads from spiders had already been made by others,



EVEN THE HUGE BUMBLEBEE FALLS VICTIM

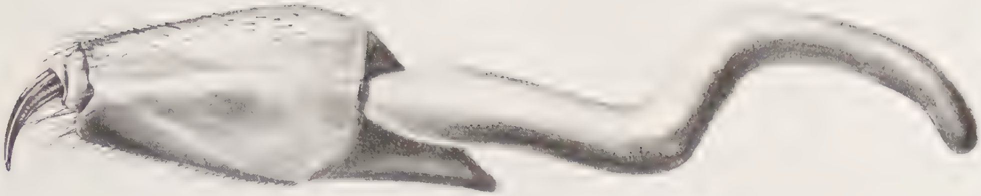
The golden garden spider quickly binds her struggling catch with silk from her spinnerets. After draining the juices from the huge carcass, she will cut the thread holding it to the net and let the empty shell fall. Her indolent mate may feed on what she leaves.



Photographs by Lynwood M. Chace

SPIDERS SOMETIMES HAVE MARITAL DIFFICULTIES

"Husbands," being much the smaller, usually get the worst of it in family fights. However, stories about females luring unsuspecting swains into their webs to gratify hunger have no foundation in fact. After the mating, the male of this pair of the Araneus clan may be devoured, but more likely he will become merely a boarder in the household.



Drawn by Hashime Murayama

OVERSIZE POISON APPARATUS MAKES THE BLACK WIDOW DANGEROUS

In many species, even in the dread tarantula, the sacs which conceal the venom are contained within the jaw structure, but in *Latrodectus mactans* (see Color Plate III) these repositories, of which each individual has two, extend far back of the jaws.

but he improved upon them. He computed that one spider would yield at successive reelings a grain of silk, that 450 spiders would produce enough thread for one yard of silk, and that 5,400 would produce enough silk for a lady's dress.

Although spider silk proved impractical for textile use, the improvement of optical instruments brought with it a real commercial need for the silk in making a precision device. In range finders, certain types of microscopes, and other optical instruments, it was highly desirable to have the circular field of vision precisely divided by as fine a line as possible. For this purpose a thread of spider silk was the best to be found.

Spider silk, used as cross-hairs in optical instruments, is taken in autumn either directly from the abdomen of the arachnid or from its cocoons. It is reeled out on open cards, which are filed away for future use. For this purpose orb weavers are used, three of the favorite species being *Epeira diademata, Zilla atrica,* and *Miranda aurantia* (see Color Plate V, lower left).

When spider silk is obtained directly from the abdomen of the spider it is usually observed to be composed of several strands. Quite frequently four such strands, coming each from one of four specialized glands, make up the thread. A skilled worker can split such a thread into its four components and get a fine element for use in instruments. Spider silk retains its elasticity for months, or even years, and when cross-hairs are in position in an instrument they may remain in use for many years.

WATER SPIDERS AND SNAKE CATCHERS

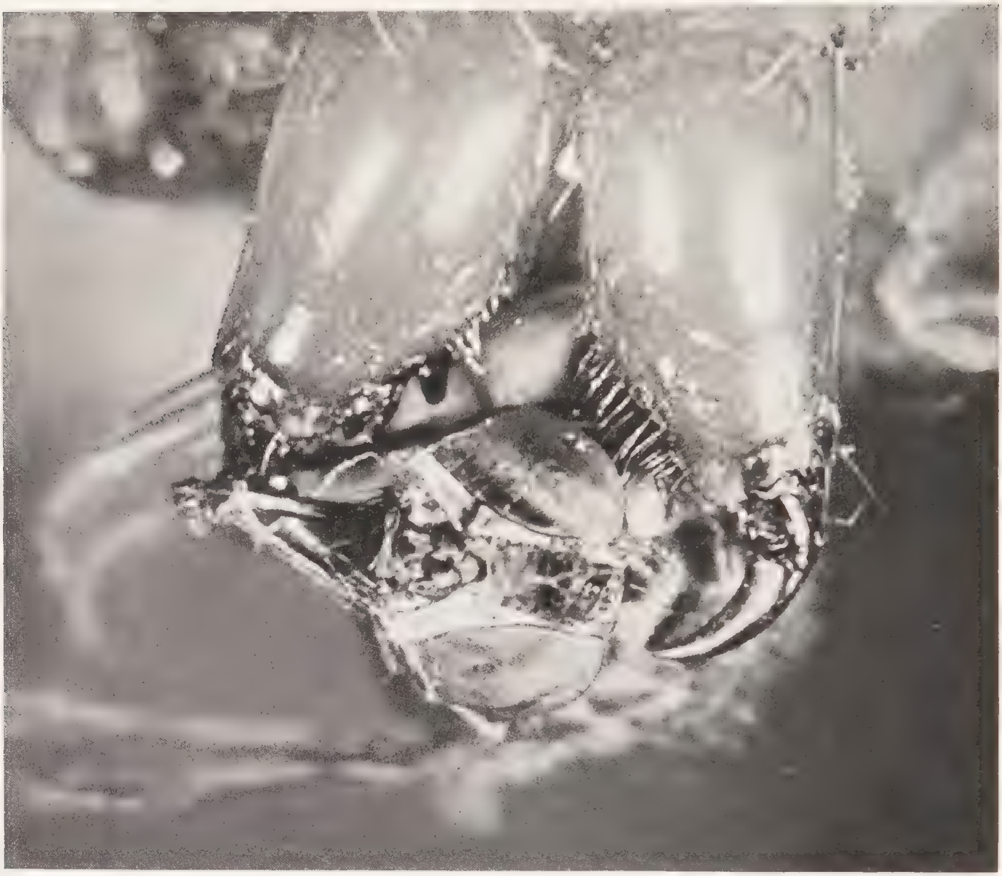
Although spiders are typical air-breathing animals, a few species have acquired the remarkable ability to descend beneath the water and remain there for long periods. The diving spider takes down with it an "oxygen tank" in the form of a large air bubble, which surrounds the whole of the abdomen and much of the cephalothorax.

A foreign species, *Argyroneta aquatica,* builds among aquatic plants a dome-shaped air container, where it devours its prey, casts its skin, mates, and lays its eggs. Fresh air is carried to this submerged domicile in bubbles brought from the surface.

One observer reports seeing a 6-inch garter snake caught in the web of *Teutana triangulosa.* Although the snake had not yet stopped writhing, the spider was feeding on it, and the sucked tissues were bloody, soft, and pulpy. The snake weighed 8 grams, the spider only 0.0225 gram after its full meal.

RELICS OF THE PAST—LIPHISTIIDAE, AVICULARIIDAE

The valiant arachnid had successfully caught a victim more than 350 times its own weight.



Photograph by Lynwood M. Chace

NO HOPE FOR THE FLY CAUGHT IN THE SPIDER'S JAWS

Fortunately for the victim, the poison which flows from the fangs will bring quick insensibility and death.

The most generalized of the spiders are the tarantulas and their kin. They breathe through two pairs of book-lungs and have powerful jaws that work up and down in a vertical, longitudinal plane. Their stout bodies are usually well clothed with hair and some Asiatic species have segmented abdomens.

These spiders live on or in the earth, make no snares for catching their prey, and are largely nocturnal. Some of them, called trapdoor spiders (see Color Plate I), protect their tunnellike nests with hinged doors.

Tarantulas occur in the warmer parts of the world. Our common Western tarantula, *Eurypelma californica* (see Color Plate II), active at night only, passes the day in its hole. As has been shown experimentally, its bite is of no serious consequence; yet its fangs are powerful enough to bring a flow of blood. Individuals of this tarantula may live 14 to 16 years, or even longer, growing during most of the time.

Our common Eastern trapdoor spider, *Pachylomerus audouini* (see Color Plate I), digs a deep hole in the ground, lines it with fine silk, and finally adds a waferlike lid of the same material as that surrounding her home. The lid is held together with silken threads and sticky material and hinged with threads of silk. Not to be confused with the California trapdoor spider (see page 195), this species is found from Maryland to Texas.

TUBE-WEB SPIDERS—ATYPIDAE

Members of the family Atypidae have been called atypical tarantulas. They are similar in shape to the true tarantulas, but are smaller and less hairy and have more conspicuous jaws. Like the tarantulas, they dwell largely in holes in the ground,

Photograph by Lynwood M. Chace

NIGHT HANGS JEWELS IN DAINTY PATTERN ON THIS WEB

The shamrock spider (see text, page 189) weaves a symmetrical orb design that lends itself to dew adornment.

but the linings of the holes are continued above the surface of the soil as silken tubes. Our most common species, the purse-web spider, *Atypus abbotii* (see Color Plate VI, L), extends its tube upward from the ground for several inches. The species is found in isolated colonies in the Eastern States, but is more common in the South.

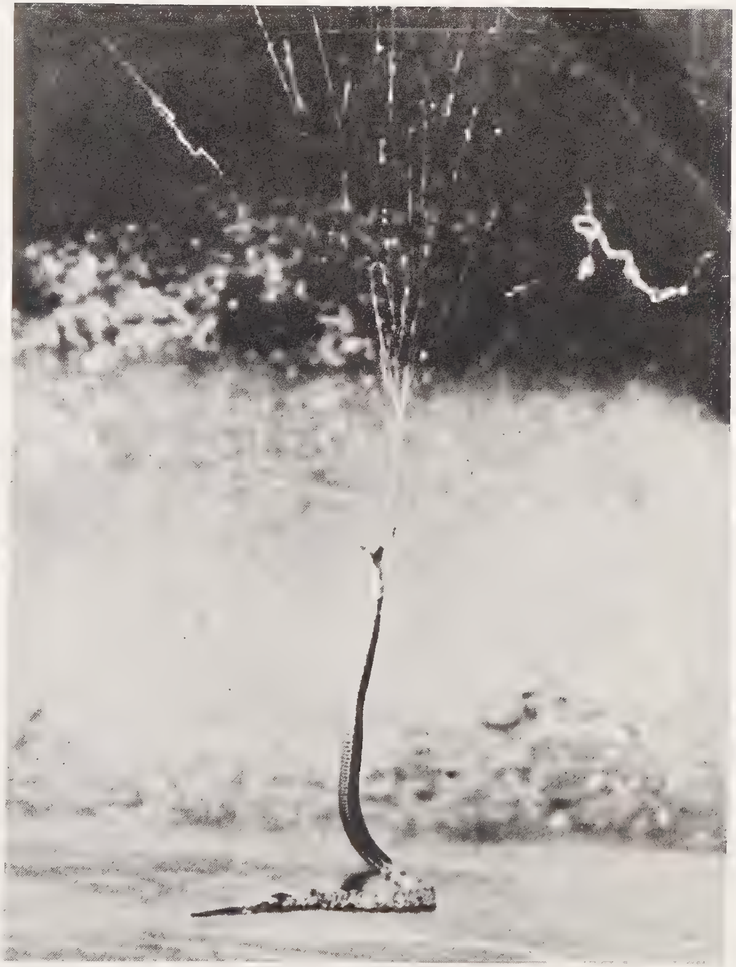
HACKLED-BAND WEAVERS—ULOBORIDAE, DICTYNIDAE, FILISTATIDAE

Pictures of inaction and desolation are never complete without spider webs stretched across some of the débris. That small geometrical web on the weeds near an abandoned farm building is the lair of an odd-looking spider of the species *Uloborus americanus* (see Color Plate VI, O). Her brushlike front legs are out of all proportion to the others.

The triangle-shaped web on the half-dead currant bush, looking exactly like a section of an orb web and having four radii and a complement of transverse strands, belongs to the triangle spider, *Hyptiotes cavatus* (see Color Plate VI, M).

Let us look closer at this web. Now we see a single line of thread running from the apex of the triangle to a twig. At the twig end of this line is the spider herself, holding fast to the twig, and pulling on the line of silk until there are loose folds between her legs. We soon see what she is up to—all set to throw a trap. When an insect touches the web she lets go of the line, and the rebounding web throws its sticky strands against the victim.

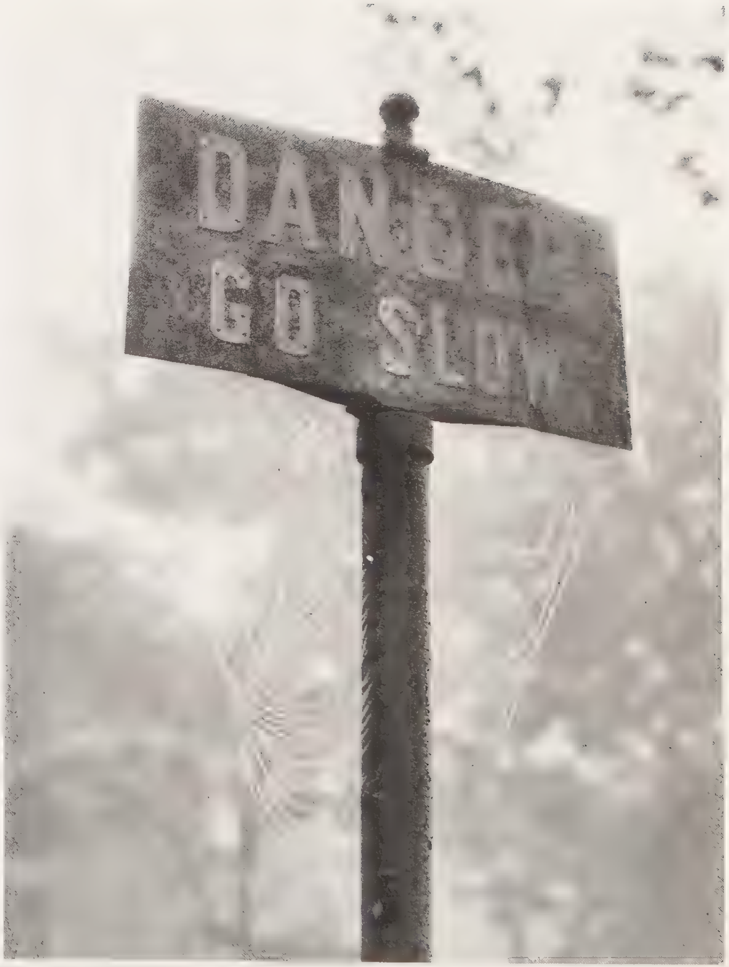
The old cellar walls of the ruins are decorated with silk-lined holes, each with its radiating strands or bands of silk. Our



Photograph from Keystone-Underwood

A PAIR OF SPIDERS CONSTITUTE THEMSELVES HANGMEN

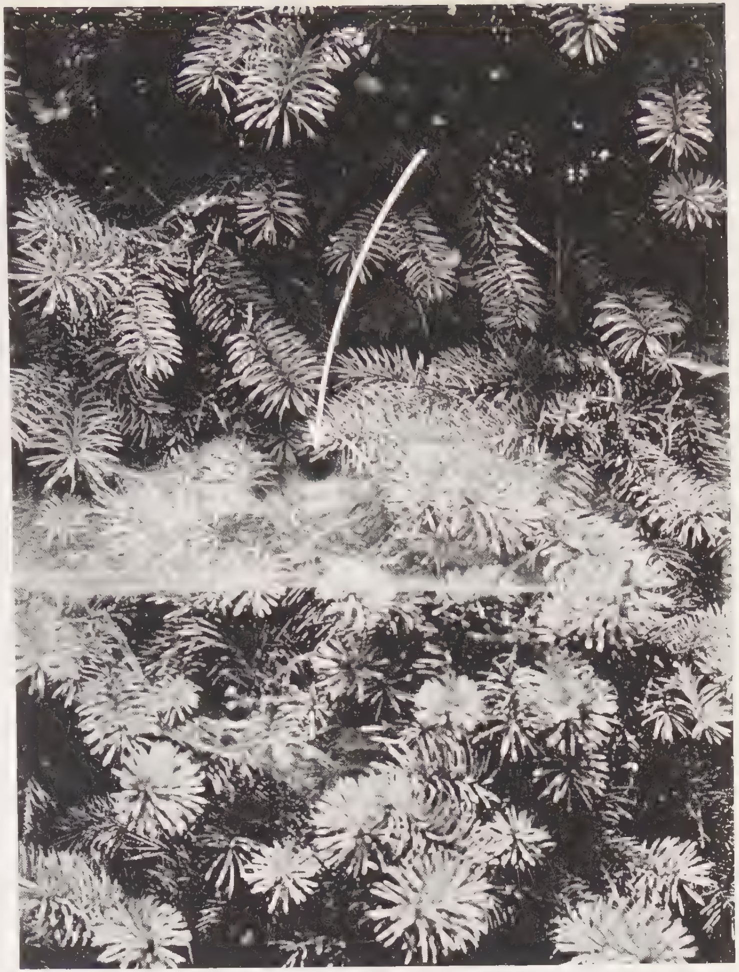
This battle was fought in a cellar at Elgin, Illinois. Probably the victim became tangled in the web accidentally as it lifted its head, and the spiders immediately bound it fast with additional threads.



Photograph by George R. King

INSECTS SHOULD HEED THE WARNING

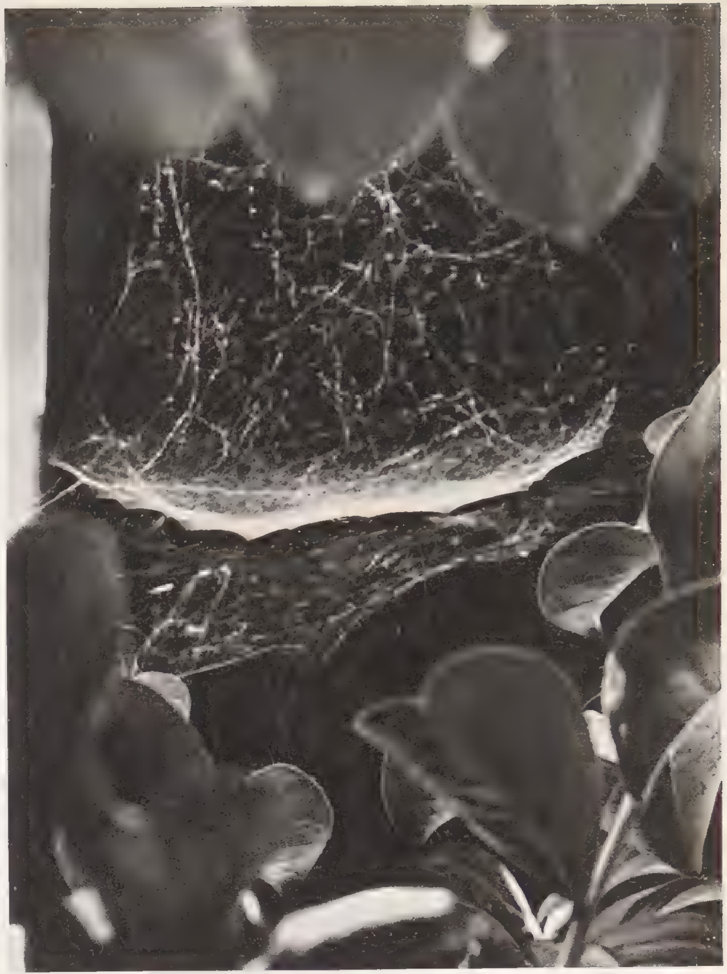
Not only motorists but small-winged creatures have reason to read this sign. The orb web on the left is in perfect condition; that on the right either was abandoned before completion or damaged after construction.



Photograph by Henry E. Ewing

THE GRASS SPIDER WEAVES A FUNNEL WEB

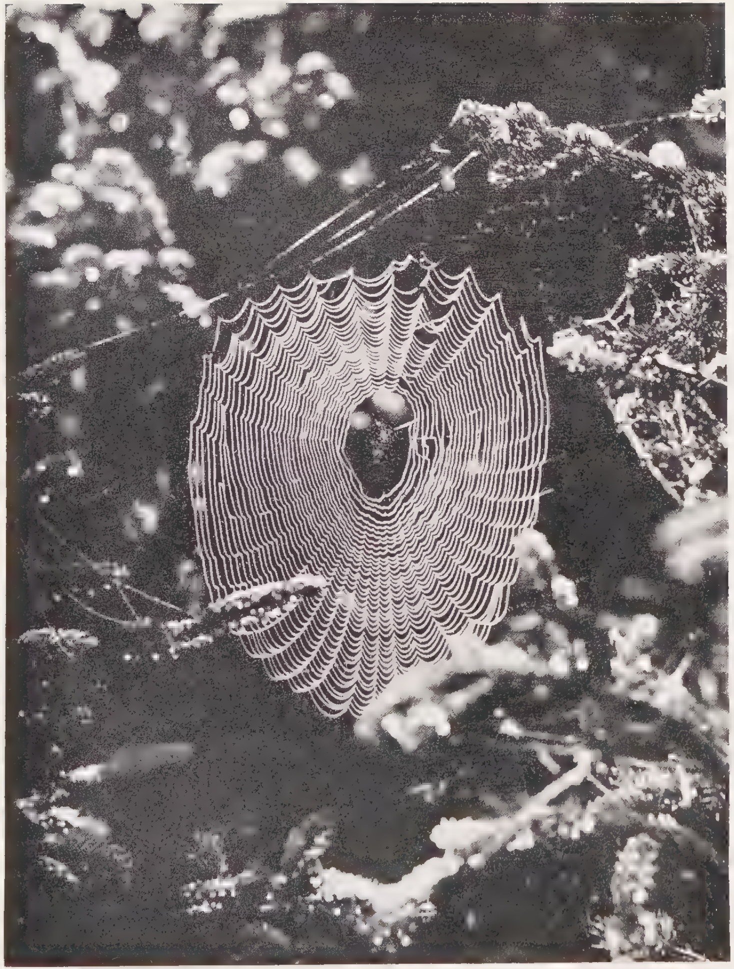
Though her home is usually on lower vegetation, this spinner sometimes builds in evergreen trees, as in this case. She sits near the mouth of the tube (at the arrow point), awaiting her victims (see text, pages 163, 191).



Photograph by Henry E. Ewing

THE BOWL AND DOILY SPIDER WEAVES A DOUBLE WEB

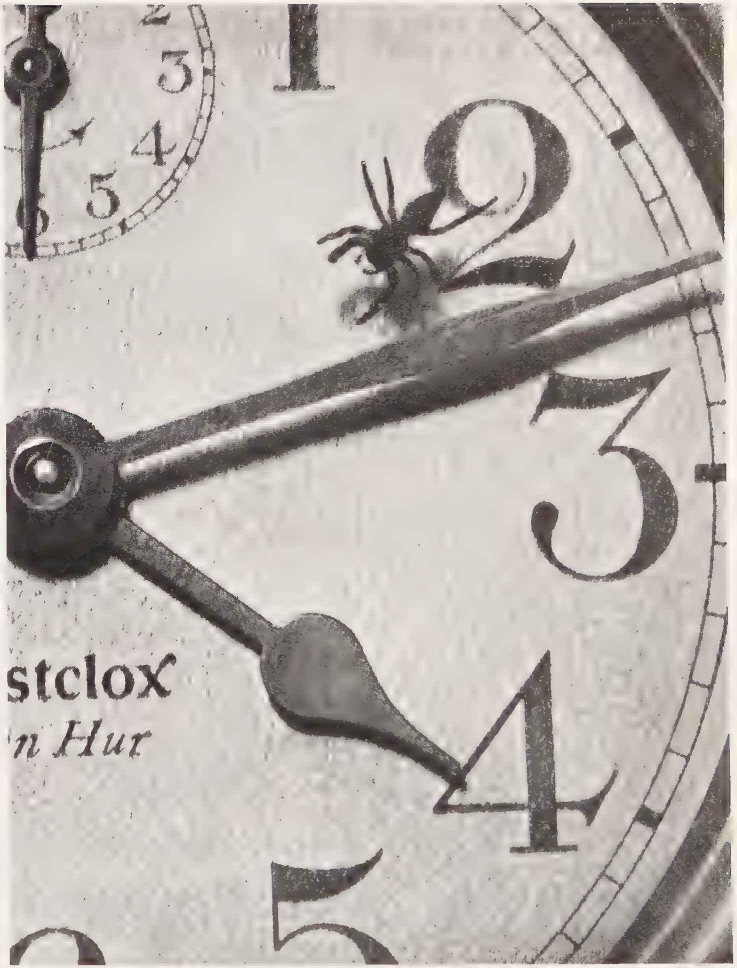
For her filmy home *Linyphia communis* spins two sheets, one above the other. The upper, or "bowl," is concave; the lower, or "doily," is a horizontal plane (see text, pages 163, 187; also compare illustration, page 186).



Photograph by H. H. Seaton

MORNING MIST MAKES A NECKLACE OF PEARLS

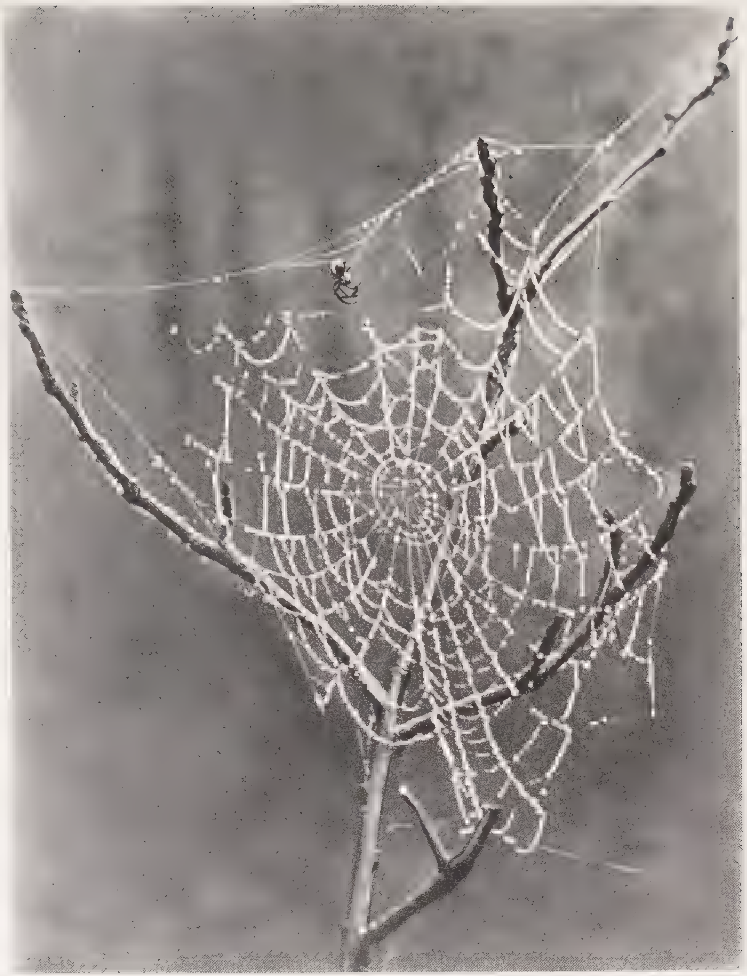
Exquisitely framed in Adirondack evergreens, this symmetrical masterpiece of the orb-weaver's spinning gleams in the sun.



Photograph from Akron Times-Press

TIME AND DISUSE BRING WEBS

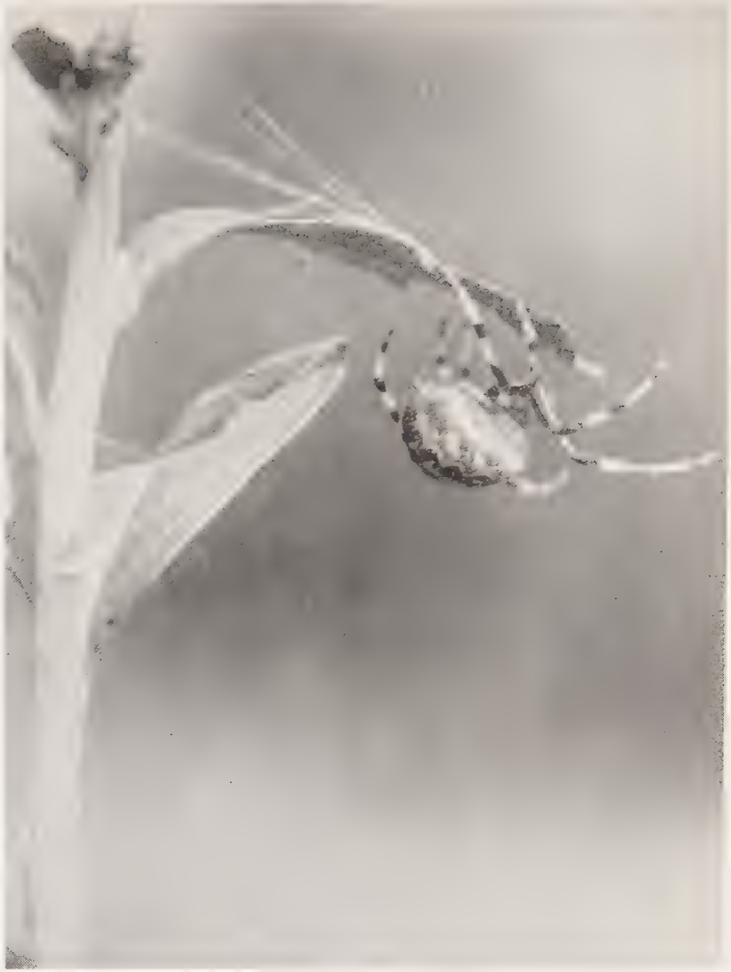
When the minute hand comes around again, disaster will overtake this spider unless she relies upon her acrobatic ability to hurdle the moving bar.



Photograph by Herbert

DEW JEWELS THE ORB WEB BUT ANNOYS THE SPIDER

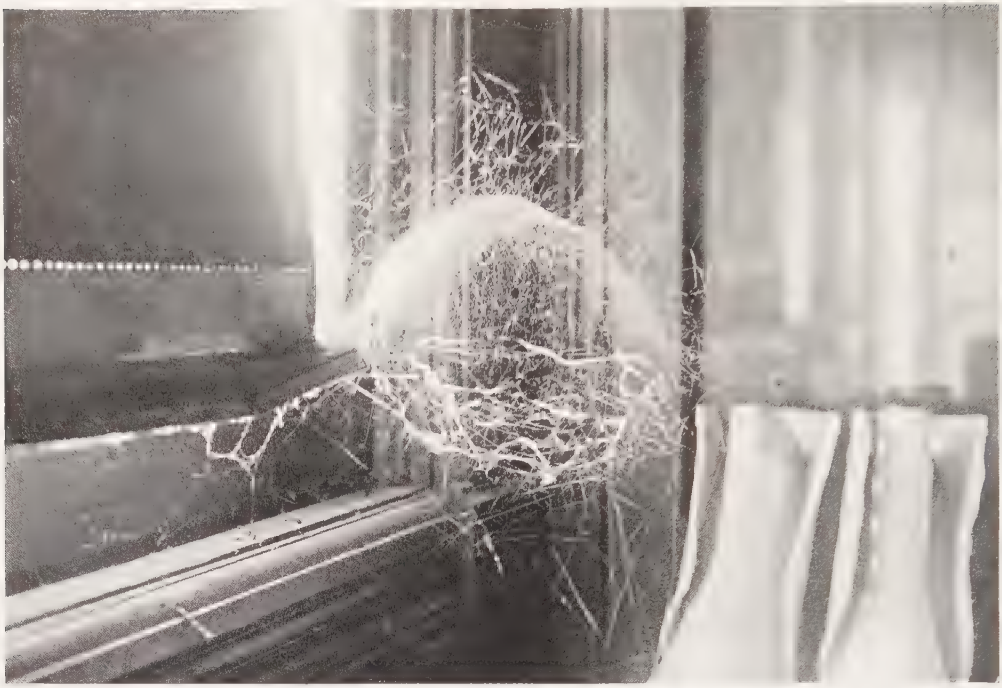
She does not appreciate the pearly drops, for they render her snare useless for catching her breakfast and cause her to go hungry till the sun dispels them.



Photograph by Lynwood M. Chace

ALL SET FOR A DOWNWARD FLIGHT

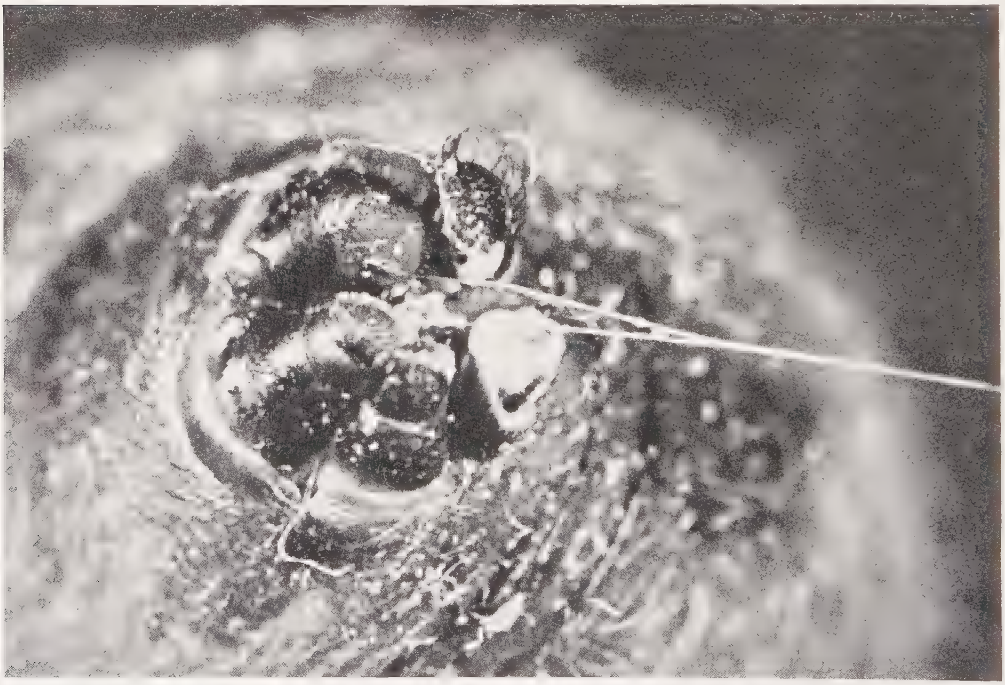
Araneus needs no parachute, for she has attached to a leaf a thread of silk which, as it spins out from her abdomen, will lower her gradually. To return, she will simply reel up her line.



Photograph by W. B. Johnstone

THE SIERRA DOME SPIDER SETS ITS SNARE FOR INSECTS IN FLIGHT

Every species has its own design peculiarly adapted to its needs. *Linyphia litigiosa* spins this inverted bowl; its cousin, *Linyphia communis,* makes a similar trap right side up (see text, pages 163, 187).



Photograph by Lynwood M. Chace

FROM SETS OF SPINNERETS THE SPIDER CONJURES HER SILK

Each of the fingerlike organs (greatly magnified in the photograph) can turn out a thread. Frequently there are not five but six in each group; the one showing white at the right is a fusion of two.

hand lens discovers three or four kinds of silk in the bands. Some of these are made by *Amaurobius bennetti* (see Color Plate VI, D). The most beautiful ones are made by *Filistata hibernalis* (see Color Plate VI, C).

SIX-EYED SPIDERS—DYSDERIDAE, SCYTODIDAE, AND OTHERS

Originally all spiders had eight eyes, but many have lost one or more pairs. A few cave species have lost all of their eyes—an important fact for those to note who believe in adaptive evolution. In *Dysdera crocata* (see Color Plate VI, G) and the other two species here mentioned, there are only six eyes. The eyes of *Dysdera crocata,* all of about the same size, are arranged in a half circle. In *Loxosceles rufescens* (see Color Plate VI, I) the eyes are arranged in three pairs. In the long-legged, subtropical *Scytodes longipes* (see Color Plate VI, Q) the six eyes are pearly white.

MOSS SPIDERS AND RELATIVES—DRASSIDAE

Members of the spider family Drassidae abound in damp woodlands, where they hide under rocks, logs, or in moss. They are eight-eyed spiders, with only two tarsal claws to a leg. The eyes are arranged in two rows. The genus *Zelotes* includes more than a hundred species. *Zelotes ater* (see Color Plate VI, J) has a shiny black abdomen and yellowish brown legs. It is distributed over all of the United States and most of North America.

SOME LONG-LEGGED SPIDERS—PHOLCIDAE

Probably the longest-legged spiders are to be found in the family Pholcidae. One very common species, *Pholcus phalangioides* (see Color Plate III), has such long legs that it is frequently taken for a daddy longlegs.

COBWEB SPIDERS AND RELATIVES—THERIDIIDAE

No journey is necessary to see the makers of cobwebs or irregular nets. The common house spider, *Theridion tepidariorum* (see Color Plate IV), is the most easily observed representative and is present in all countries of temperate climate.

While we are studying the house spider we may find some irregular strands of silk in the lower angle of a window with a specimen of *Teutana triangulosa* (see Color Plate VIII, H) on them. This spider has a strong hankering for the lower angle of a window.

Most of the makers of the irregular nets deserve our confidence and friendship, though the venomous members of the genus *Latrodectus* should be left alone. The false black widow, *Steatoda borealis* (see Color Plate VI, F), may frighten the timid or uninformed, but this near relative of the black widow, *Latrodectus mactans* (see page 175), is entirely harmless.

SHEET-WEB WEAVERS—LINYPHIIDAE

One summer, at my Maryland home, a bowl and doily spider, *Linyphia communis* (see Color Plate VIII, L), made her web on a sweet-pea vine directly in front of the porch swing. Whenever I rested in the swing that summer I had a ring-side seat for observing this dainty little sheet-web weaver. She built a snare composed of two sheets (see page 183), one above the other. The upper sheet was strongly concave and the lower flat and almost horizontal. The female clung to the underside of the "bowl," ready, when a victim was snared, to force her fangs or her entire body through the silken mesh.

A near relative of the bowl and doily spider is our hammock spider, *Linyphia phrygiana* (see Color Plate VI, E), which constructs a netted sheet more or less quadrangular and suggesting a hammock.

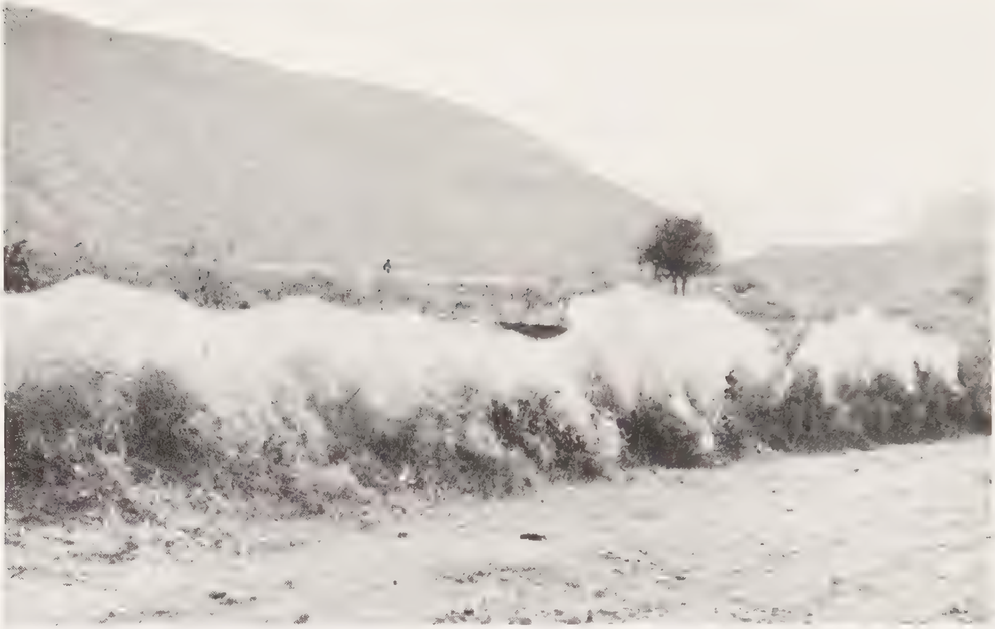
SPINY-JAWED SPIDERS—ARGIOPIDAE; TETRAGNATHINAE

The spiny-jawed spiders, particularly the males, are remarkable for their jaw development. The jaws are not only much enlarged, but are thrust out in front of the body and provided with conspicuous spines. Most spiny-jawed species are rather small; yet to their little victims they must appear most ferocious.

Tetragnatha laboriosa (see Color Plate VIII, I) is common in meadows, where it spins an orb web. It is distributed from Alaska to the West Indies. The extreme characteristics of the spiny-jawed spiders are exhibited in *Tetragnatha elongata* (see Color Plate VIII, J), a species found in damp situations throughout the United States and most of North America.

A HORIZONTAL ORB-WEB WEAVER AND ITS RELATIVES—ARGIOPIDAE; METINAE

One August morning, in a sunshiny woodland lane near the Potomac River above



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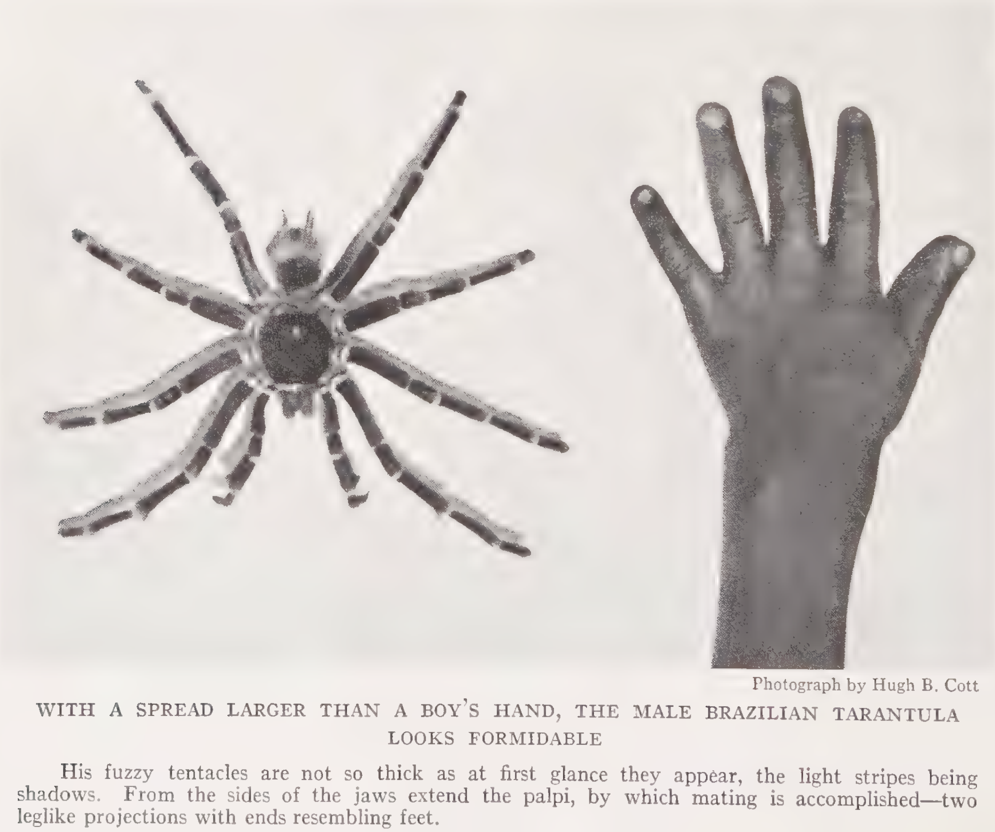
GOSSAMER BLANKETS ENHANCE THE CHARM OF THE SILKEN EAST

In the Hangu Valley, India, spiders spread their filmy lace so thickly over large patches of low-growing vegetation as to conceal the foliage. Dew does not form here; the whiteness of the webs is due to the extraordinary multiplicity of the strands.



Photograph by Hugh B. Cott

WITH A SPREAD LARGER THAN A BOY'S HAND, THE MALE BRAZILIAN TARANTULA LOOKS FORMIDABLE

His fuzzy tentacles are not so thick as at first glance they appear, the light stripes being shadows. From the sides of the jaws extend the palpi, by which mating is accomplished—two leglike projections with ends resembling feet.

Great Falls, I came upon many finely spun, beautifully woven orb webs placed almost or entirely in horizontal position. Looking closely at some of these webs, I found a most exquisitely colored spider. It was a bright green with an elaborate design of silvery white, tinted with gold, and spotted below with coppery red.

This spider beauty was *Leucauge venusta* (see Color Plate VIII, G), one of the most strikingly decorated of all our spiders. It has a Mexican cousin, *Leucauge lugens* (see Plate VIII, M), in which the beauty is marred by the presence of a peculiar taillike projection at the tip of the abdomen.

SILK SPIDERS—ARGIOPIDAE; NEPHILINAE

All spiders spin silk, but members of the subfamily Nephilinae spin so much that they have been used in the attempts to establish a spider-silk industry (see text, page 177). The one well-known species found in the United States is the brush-legged spider, *Nephila clavipes* (see Color Plate VI, B). No spider is more easily recognized than this large orb weaver. Each leg, except those of the third pair, bears one or more whorls of fine setæ, so arranged as to suggest a bottle brush. A foreign species of the same genus, *Nephila*, was once observed catching a bird in its web (see page 190).

GARDEN SPIDERS—ARGIOPIDAE; ARGIOPINAE

When I was a boy in the Middle West I observed a garden spider that spread its beautiful geometrical web across my mother's flower bed. The creature's size, its brilliant golden markings, and the expanse of its web compelled my attention.

Although the web was entangled among some of the most prized flowers of the garden, the spider was not disturbed, for young grasshoppers made up most of its diet.

Garden spiders build geometrical webs almost vertical in position and frequently as much as two feet in diameter. The snares, placed on low-growing vegetation, have at the center vertical zigzag bands of glistening white silk. Here the female patiently rests, head downward.

By far the most common species in the United States is the golden garden spider, *Miranda aurantia* (see Color Plate V, below, left). The female is more than an inch long, but the male (see Color Plate V, below, inset) is puny, being scarcely a fourth as long as the female and sometimes only a fiftieth of her weight. Less common is the banded garden spider, *Metargiope trifasciata* (see Plate V, below, right), a whitish species tinged with yellow and conspicuously marked with irregular dark bands.

In the silvered garden spider, *Argiope argentata* (see Color Plate VIII, E), the abdomen of the female is produced laterally into three pairs of large tuberclelike lobes.

TYPICAL ORB WEAVERS—ARGIOPIDAE; ARANEINAE

In open places and among flowers, where there are many flying insects, the typical orb weavers abound. *Araneus benjaminus* (see Color Plate VI, A) is common in Maryland and Virginia flower gardens. Its generic brother, *Araneus vulgaris* (see Color Plate VI, N), also loves the flower garden. The lattice spider, *Araneus thaddeus* (see Color Plate VI, P), builds a beautiful latticelike web, stretched across the underside of a slightly curled leaf.

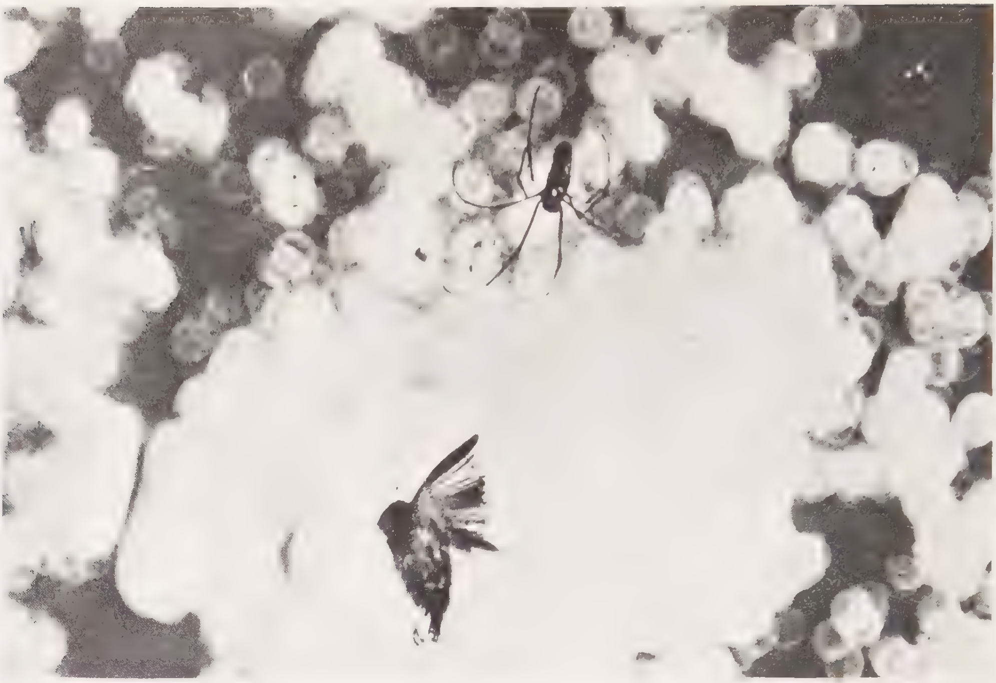
As we pass along the hedges we may find the beautiful labyrinth spider, *Araneus labyrintheus* (see Color Plate VI, K), which builds two distinct types of webs situated together, thus having a composite home.

The most permanent part of this double house is an irregular net of the type built by the cobweb weavers. To this is added an incomplete orb. Near the central part of the irregular net the female builds a retreat and concealment nest of a few small dead leaves tied together with silk.

In a ramble in summer sunshine we may find the star spider, *Araneus stellatus* (see Color Plate VIII, K), which has about a dozen spinelike tubercles around the margin of the abdomen; but to see the gorgeous shamrock spider, *Araneus trifolium* (see Color Plate VI, H), we must make a trip in the autumn. This spider frequently has a three-lobed spot, shaped like a clover leaf, on the middle of the anterior half of the abdomen.

SPINED SPIDERS—ARGIOPIDAE; GASTERACANTHINAE

If you live in one of the Southern States, take a walk in the woods some bright summer afternoon. Suddenly you will come upon a large geometrical web stretched from one branch to another. At the very hub of



Photograph by William Palmer

SUCH JUNGLE TRAGEDY AS THIS, IN JAVA, IS UNUSUAL

Seldom does a snare-weaving spider catch a bird. The little flower pecker has flown into the web of a large *Nephila*.

the web is a black and yellow object resembling a bur. This spined object is the female of the spined spider, *Gasteracantha cancriformis* (see Color Plate VIII, B).

Most of our spined spiders, however, have a longer body than this one and do not resemble a bur so closely. *Micrathena reduviana* (see Color Plate VIII, A) has only two pairs of spines, both very small.

The spear-head spider, *Micrathena sagittata* (see Color Plate VIII, D), has three conspicuous spines. The tropical spear-head spider, *Micrathena obtusospina* (see Color Plate VIII, F), has only two pairs, but they are enormous. *Micrathena gracilis* (see Color Plate VIII, C) has five pairs.

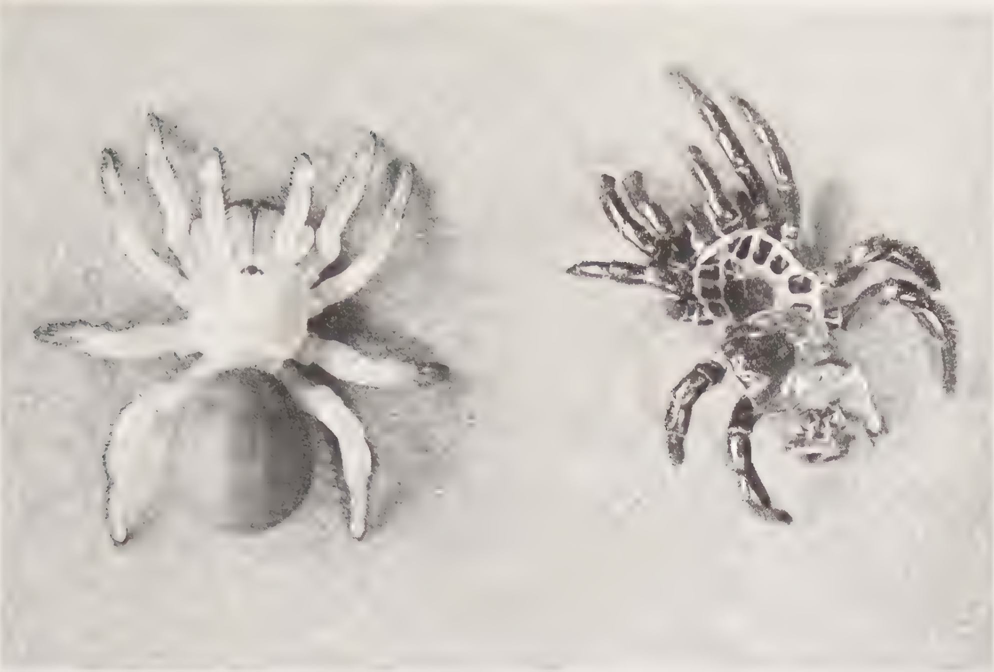
CRAB SPIDERS, LARGE AND SMALL—THOMISIDAE AND HETEROPODIDAE

Crab spiders are so named because of their resemblance in shape to crabs. The likeness results from the flattening of the body and the assumption of a lateral direction by the legs. One species, *Misumenoides aleatorius* (see Color Plate VII, A), lives in flowers. It may be almost uniformly white or yellow or strikingly marked with reddish brown above. This spider has a tendency to take on the color of the flower it inhabits, thus becoming almost invisible.

The genus *Xysticus* (see Color Plate VII, D) includes about a third of all our crab spiders. Members of this genus are usually either fawn-colored or brownish. Their life is spent in seclusion, under stones or the loose bark of trees, or in other situations away from the eyes of enemies. The angulate crab spider, *Tmarus angulatus* (see Color Plate VIII, O), differs decidedly from most of the other members of the family in having the abdomen high and pointed behind.

Related to the true crab spiders are the members of the family Heteropodidae, known as the giant crab spiders. They also have the legs extending laterally from the body.

The best-known member of the group is the large banana spider, *Heteropoda venatoria* (see Color Plate VII, F). This is a tropical species that frequently arrives in our northern cities on bunches of bananas and is commonly mistaken for a tarantula. Its bite is sharply painful, but not dangerous.



© Lee Passmore

A FEMALE SPIDER FIVE MINUTES AFTER SHEDDING

She appeared like a wax model and was almost transparent, as she rested by her cast-off covering at the right.

The female makes a flat, waferlike egg sac, which she carries about under her body by means of her mouth parts. Once I took an egg sac from a female banana spider and gave her in its place a substitute of the same size and shape which I had whittled out of pine. She readily accepted the imitation sac.

WANDERERS AND STAY-AT-HOMES—CTENIDAE AND CLUBIONIDAE

Spiders of the small family Ctenidae love to roam. One of these ramblers, *Anahita punctulata* (see Color Plate VII, G), is found in the Southern States.

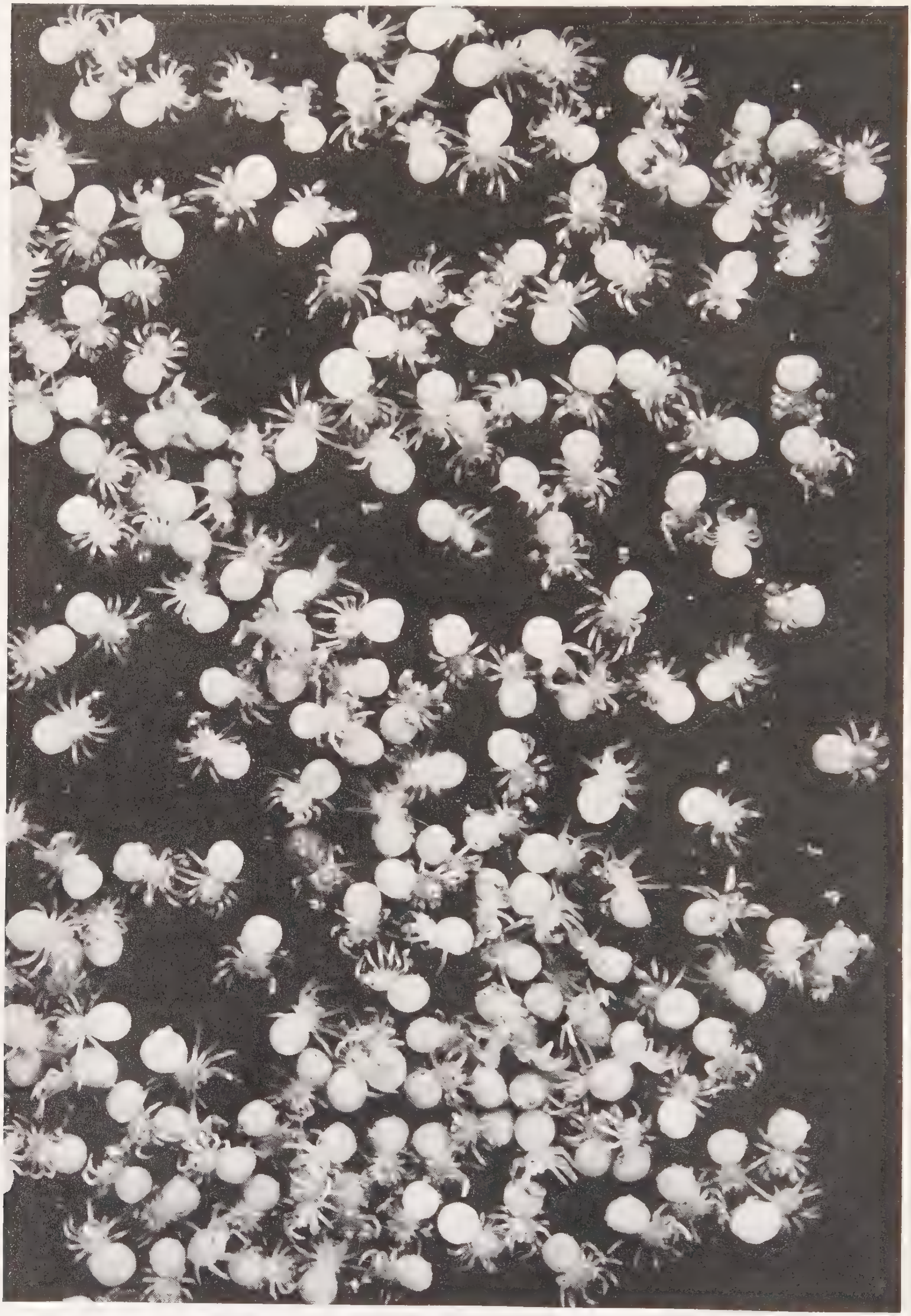
Far different in their disposition are the members of the family Clubionidae. They appear to be possessed of an inferiority complex. One of them will roll up a leaf and hide away in it as if all the world were gloomy and sinister. Another will pick out a cranny in the side of a cliff or wall, seeking in this manner his solace and quiet. Many of the species are less retiring and some are light-colored, with conspicuous black cushions of hairs at the tips of the legs. One species, *Castaneira descripta,* is pictured in Color Plate VII, E.

Funnel-web spiders (Agelenidae) abound in summer wherever there are moisture and vegetation. Usually they build near the ground; or, if far above the ground, in a thick growth of vegetation such as a hedge or an evergreen tree. Our common grass spider, *Agelena naevia* (see Color Plate VII, H), is the best-known funnel-web maker. It is common in many places in the United States. The tube of its web (see page 183) almost invariably leads back into a thick growth of vegetation. Thus, when the spider retreats, it is safe from its enemies.

A small cousin of the grass spider is *Coelotes fidelis* (see Color Plate VII, K), which does not spin a perfect funnel web.

DIVING SPIDERS AND THEIR RELATIVES—PISAURIDAE

Some of the members of the family Pisauridae are called diving spiders. They belong to the genus *Dolomedes* and make interesting aquaria inhabitants. I have kept several individuals of *Dolomedes triton* (see Color Plate VII, L) at different times in large aquaria jars. This species is called the six-spotted diving spider and is the most striking in color and marking.



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NEWLY HATCHED TRAPDOOR SPIDERS RESEMBLE PEARLS EQUIPPED WITH WRIGGLING LEGS

The spiderlings change color as they grow older, becoming pale pink and then a darker shade. A little later, although they are no larger than grains of rice, they can spray a tiny web from their spinnerets and build a miniature nest. Few of the original 300 spiderlings live to maturity. Sometimes the mother will crush one of her offspring between her jaws, so that the other members of her family may partake of the juices. The figures are enlarged about four times.

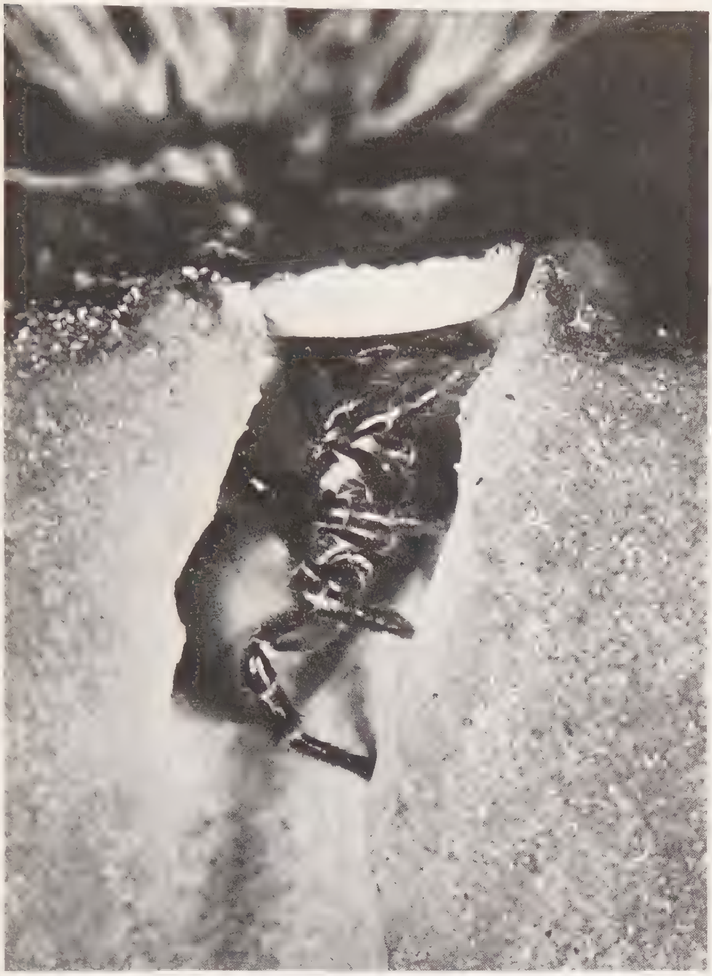
One female kept in an aquarium, where she had been supplied vegetation above the water, lived for months and made her spherical egg sac. This she held closely in her mouth parts and only once could she be induced to drop it to feed.

Dolomedes urinator (see Color Plate VII, C) is rather somber-colored. It is found in marshy places in the eastern part of the United States.

WOLF SPIDERS—LYCOSIDAE

Spring is the time for wolf spiders. They may be found running through the grass, along woodland paths, and in many other places. They catch their prey by chasing and springing catlike upon victims.

The maternal instinct is best developed in this group. Not only do the females carry their egg sacs with them, firmly attached to the spinnerets by bundles of silken threads, but the young spiders are carried upon their mother's back for days after hatching. *Lycosa punctulata* (see Color Plate VII, B) is a striped species common in the eastern part of the United States.



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A TRAPDOOR SPIDER ON WATCH

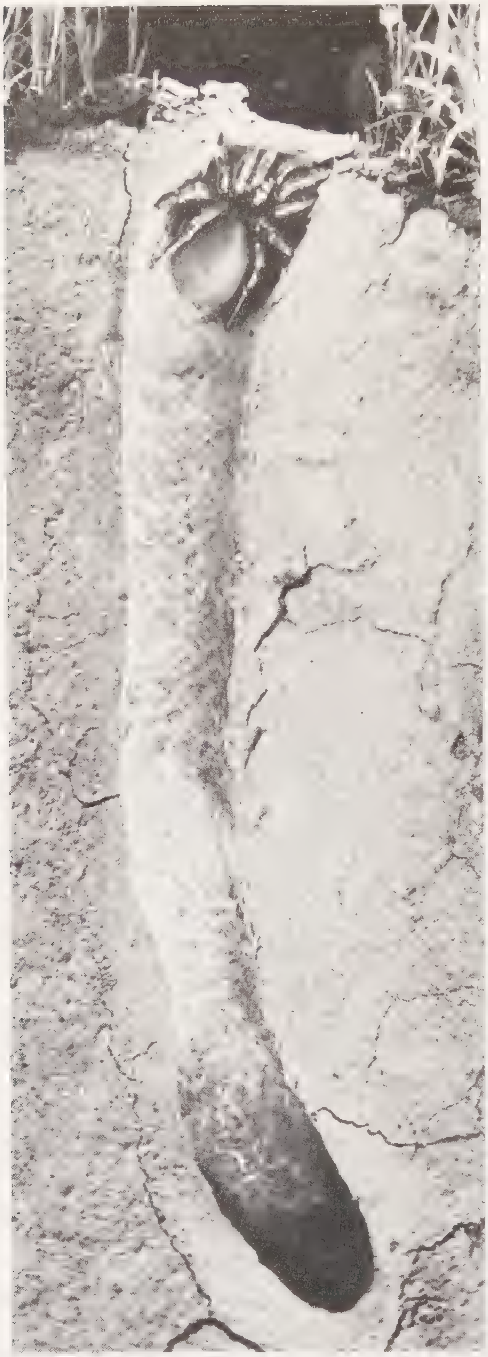
A spider will remain for hours with the lid slightly raised, while she waits for her prey. When the vibrations set up by the footfalls of an approaching insect warn her, she leaps out and grasps her victim. Movement is so rapid the eye can scarcely follow.

LYNX SPIDERS—OXYOPIDAE

Members of the small family Oxyopidae chase their prey swiftly among trees and shrubs, even leaping from one branch to another. Their legs are long and each is armed with three terminal claws. The eyes are eight in number, dark in color, and unequal in size. *Peucetia viridans* (see Color Plate VII, J) is a most beautiful representative of the group. It is a large species, having a bright, transparent green as a background color and markings of red, brown, and black.

ACROBATS AND MIMICS—ATTIDAE

One warm spring morning, as I was passing along one of the drives in the Zoölogical Park at Washington, I saw a large specimen of the audacious jumping spider, *Phidippus audax* (see Color Plate VII, I) sitting on top of a fence post. As I reached out to collect her in my insect bottle, she followed my hand with her eyes. No matter the direction from which I approached, she always changed her position and faced my hand. Finally she was captured and I decided to make a pet of her.



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A TRAPDOOR SPIDER IN HER LAIR

The indentations made by the spider's fangs are visible through the silken lining. The spider is in the position in which she waits under her door for her prey. The soil in which the nest was built was gray adobe. This nest is about two-thirds natural size.

On many occasions this spider attacked and captured victims twice her size. She would pay no attention to a fly until it was within a few inches. Then her eyes would be fixed on the victim, following its every movement for a few seconds. At length a well-aimed leap ended the affair.

Before a jumping spider jumps it always fastens a line of silk to its resting place. Thus, however far it may go over a precipice, it is always safe from a fall. By means of the silken line, it can regain its former position.

In *Phidippus clarus* (see Color Plate VII, M) the female has the cephalothorax and abdomen red, and the male has only the abdomen red, the rest of the body being black.

Certain jumping spiders, as well as other kinds, have a remarkable ability to mimic ants, a fact unknown to me during my early experience as an entomologist.

This mimicry is not usually in appearance only, but frequently it is in the movements of the body as well; and it is not confined to any one family or group of spiders, but occurs in several of them.

Among the jumping spiders, or Attidae, mimicry is probably most prevalent. The mimicry may be confined to one sex or it may involve both sexes. It may be a general imitation (*i. e.,* a spider may take on an external form somewhat similar to that of many ant species), or specific aping by one spider of a single ant species.

In the case of the common ant spider, *Synemosyna formica* (see Color Plate VIII, N), the antlike appearance is brought about by the unusual shape and rather small size of the cephalothorax, which in these respects resembles the ant's head; by the narrowing of the anterior part of the abdomen to suggest the ant's waist; and by attenuation of the front legs, which are held in such a manner as to suggest the antennæ of an ant.

In addition to these changes in form, certain color markings aid in making the deception nearly perfect. Thus the front legs look narrower than they really are because of their white outer margins. The same thing is true of the anterior part of the abdomen.

The advantage gained by this mimicry is important where the mimicked ant species is pugnacious and unpalatable. Some tropical species repeatedly fool experienced entomologists; even a hand lens does not easily aid in the recognition of Nature's deception.

CALIFORNIA TRAPDOOR SPIDER PERFORMS ENGINEERING MARVELS

By Lee Passmore

August, 1933

CALIFORNIA TRAPDOOR SPIDER PERFORMS ENGINEERING MARVELS

By Lee Passmore

With Illustrations from Photographs by the Author and F. E. Beck

RETURNING one May evening from a ramble over the southern California foothills, I came across a young man busily digging in a small mossy knoll. He was so engrossed in his work that he did not become aware of my presence until my shadow fell upon the object which was attracting his attention.

With apologies for my intrusion, I asked what he was digging. He turned with a pleasant smile and replied, "Trapdoor spiders."

Then, reaching down into the hole, he handed me a strange tubular object, warning me that it was exceedingly fragile—an exceptionally fine specimen of a cork-type spider's nest.

The burrow, or nest, about ten inches long by one and a half inches wide, was built in adobe soil. Fitting neatly in its upper end was a door, hinged with tough web. The under surface of this cover and the walls of the tube were lined with smooth, silky web of lustrous, velvety appearance.

THE SPIDER HOLDS HER TRAPDOOR SHUT

I had difficulty in raising the door; the owner of the nest strenuously objected!

The spider had placed her two fangs in the holes she had made in the under side of the lid and, bracing herself, held on for dear life. Even after my superior strength had overcome hers, she allowed herself to be lifted partly out of her nest before she let go and dropped back into the dark interior. As soon as I let the door snap into place, she returned and got another grip.

This chance meeting was the beginning of my close association with Francis Beck, who for 13 years has studied the habits of the common California trapdoor spider (*Bothriocyrtum californicum*). So deeply interested was I with the specimen shown me that I gladly accepted his invitation to inspect his collection.

I found him working at his home next day under the trees, where he had placed in a natural setting the many specimens which he had brought from the neighboring hills. Here, in boxes of adobe soil, I saw big spiders, little spiders, young and old, in dozens of "transplanted" nests. There were several hundred young ones, which had been hatched during their parents' captivity from eggs contained in the nests at the time of their removal (see illustration, page 197).

Ever alert and watchful, trapdoor spiders are extremely sensitive to the vibrations of insects as they walk over the ground or moss. They seem to know the right instant to raise the door, spring out, and make a capture. Then, dropping back to the bottom of the burrow, they feast at leisure. Movement is so rapid that the insect is within the grasp of the hungry spider before the victim can escape (see illustration, page 199).

Hundreds of sow bugs and other nocturnal insects relished by the spiders are captured by Mr. Beck and guided over the ground close to the doors of the nests to provide food for his charges.

A trapdoor spider is careful not to let the door close behind her when she is making a capture, for the cover is difficult to reopen, once it snaps shut. The door fits so tightly in the tube that there is only a fine crack where a claw could be inserted to lift it. To forestall being locked out of her own home, the spider always leaves her hind legs and a part of her abdomen under the open door (see illustration, page 199).

PATIENCE AND WATCHFUL WAITING REVEAL INGENIOUS NESTS

Considerable patience is necessary to study the habits of trapdoor spiders. Many hours of watchful waiting and sometimes whole nights pass without even a glimpse of a wary spider. It is discouraging to sit in a cramped position for hours, with eyes concentrated on a particular trapdoor, only to discover that this is one of the nights the spider is not inclined to labor.

On many occasions we have returned home after tramping for miles over good spider territory without finding a single nest, so cleverly are they hidden.

© Lee Passmore

THE TREASURE IS A TRAPDOOR SPIDER'S NEST

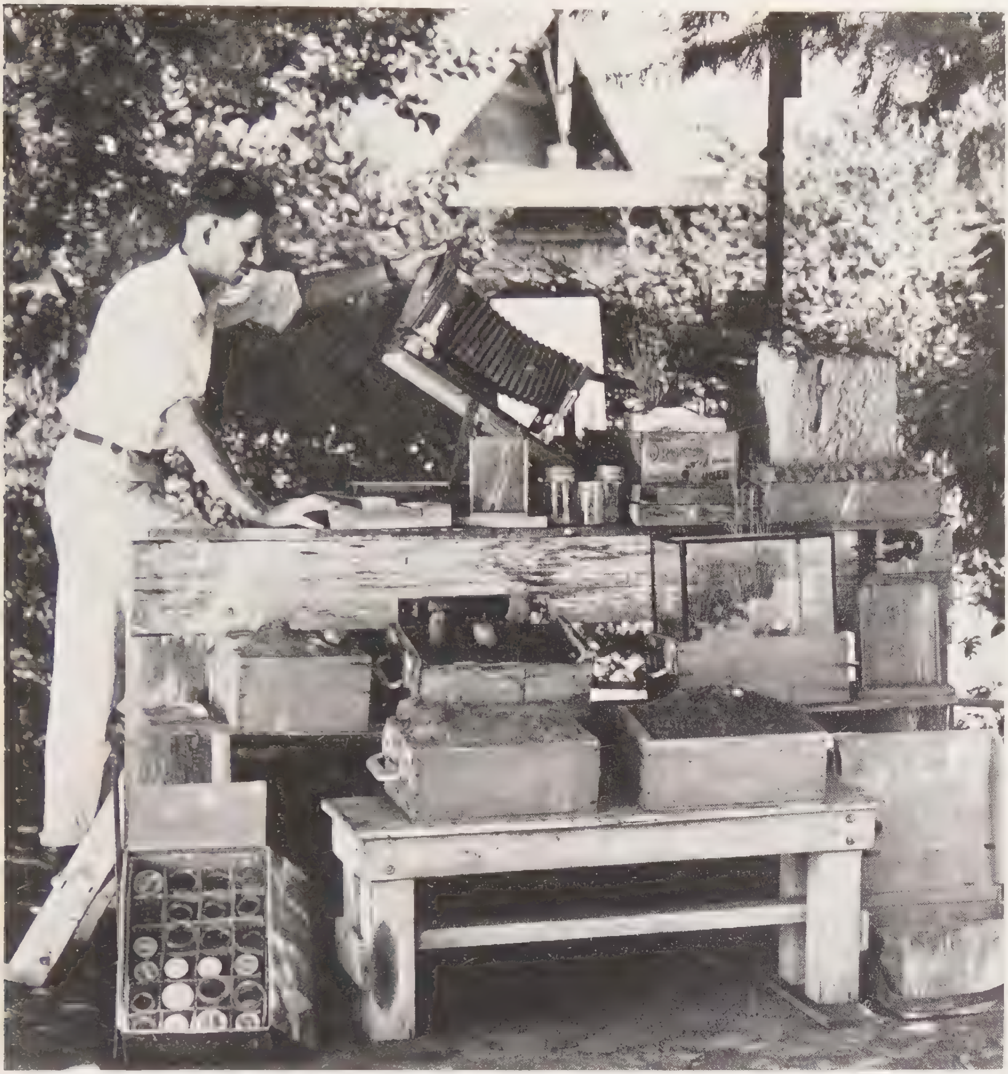
Francis E. Beck holds a nest which he has just removed from the gray adobe soil of the southern California foothills. Numerous little mounds scattered over an area of several miles formed an ideal location for the colonies of spiders. They seemed to know the protection afforded, for no water could stand on these knolls and the slope was just enough to drain without washouts.

Sixteen species of trapdoor spiders have been found by naturalists in the United States. Of these, eight are recorded exclusively from California. Others occur throughout the Southern and Southwestern States, with one species occurring as far north in Virginia as the Potomac (see Color Plate I).

Trapdoor spiders prefer high, dry ground for their nests; but even then they are not present unless conditions are favorable. They have been known to vanish from their natural habitat when virgin land is opened to farming. Probably plowing and cultivating destroy the nests and kill the spiders.

Some species of these spiders, which are almost identical with those that build doors to their nests, construct a home similar to that of their relatives, but with no trapdoor.

Mr. Beck found his first trapdoor spider accidentally in Balboa Park, San Diego. He was attracted to an object which resembled a silver half-dollar lying on the ground. Stooping to pick it up, he dis-



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A HOMEMADE ZOO FOR TRAPDOOR SPIDERS

The boxes contain "transplanted" or captive spiders living in their nests within blocks of adobe earth, dug from the field. Hundreds of sow bugs are caught and fed to the spiders by placing them on the ground near the trapdoors. The spiders crouch below, and when they feel or hear an insect approach they spring out and make a capture.

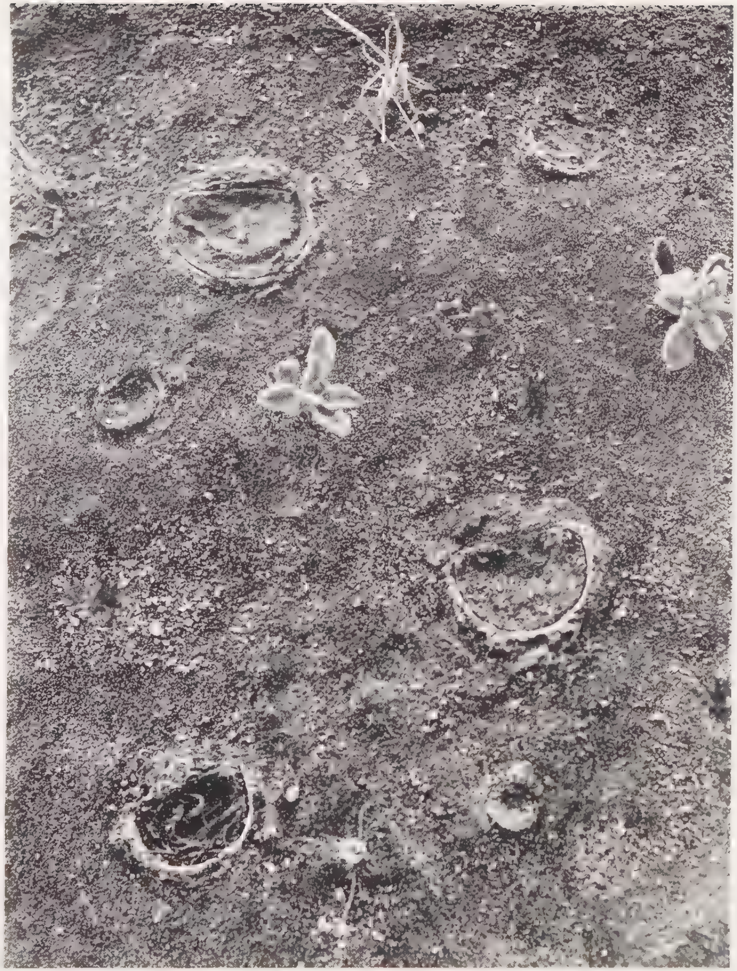
covered it was an abandoned door to a spider's nest. Beside it was a new door. Inserting his knife between the door and the inner side of the tubelike opening, he finally succeeded in lifting the lid and found the owner clinging to the under side.

The next time he went to the nest he was prepared to dig spider and home out of the ground. He trenched around the tube, keeping far enough away to avoid injuring it, until he could lift out the entire block of earth. After cutting away the outer covering of soil, he exposed a perfect web nest of the female spider. The lady had not been harmed in any way, and, "transplanted" to Mr. Beck's nursery, she became his first specimen.

MALE PREFERS BACHELOR APARTMENTS

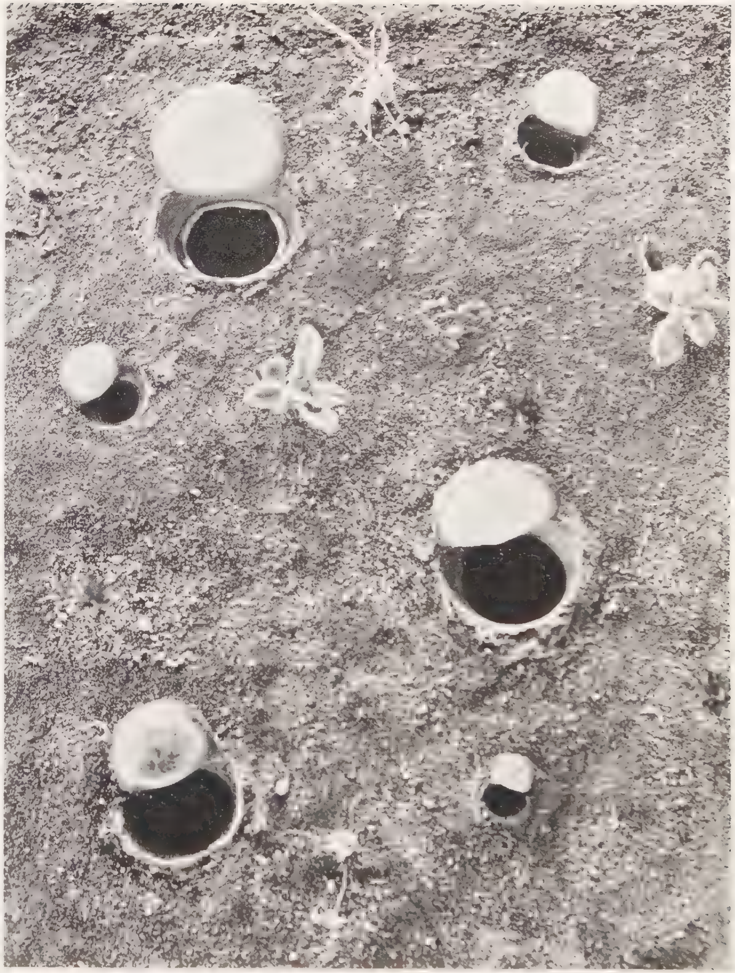
After the first year in captivity, she raised no young, although she deposited eggs regularly. These she devoured, for she apparently knew that they were infertile.

The male spider does not inhabit the same nest with the female, so we looked elsewhere for him.



A TRAPDOOR SPIDER COLONY WELL CAMOUFLAGED

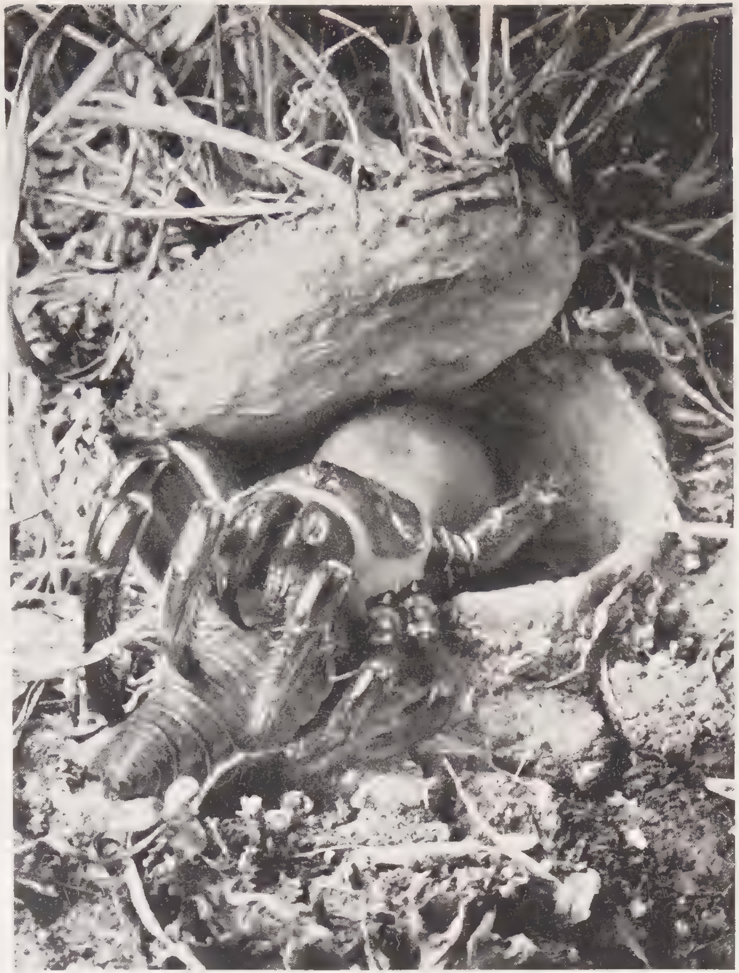
The female spider deftly covers the top of her trapdoor with earth similar to the surrounding surface, to hide it from the view of unsuspecting sow bugs, grasshoppers, and other favorite insects. If the nest is located in mossy soil, the spider will stick the roots of living moss into the door as expertly as a true gardener. The nests vary in depth from two to nine inches, depending upon the age of the spider



Photographs © Lee Passmore

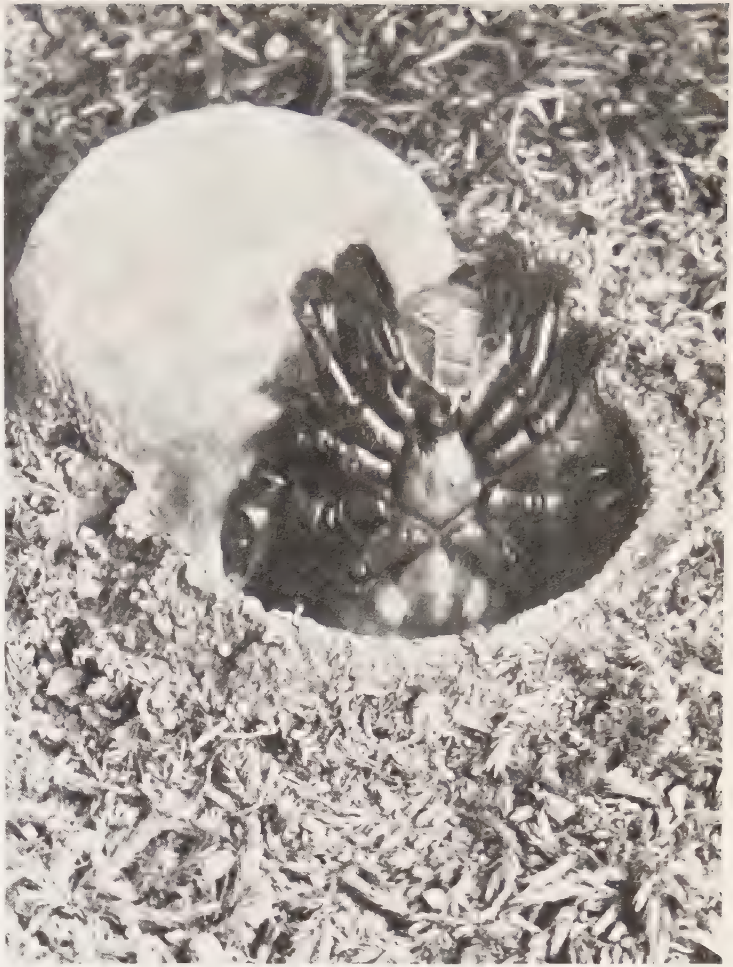
THESE TRAPDOORS WERE OPENED BY HAND

Female spiders living as close together as this seldom see their next-door neighbors (see illustration opposite). They never voluntarily come out of their nests and crawl around the ground. When feeding at night, the door is open only for a fraction of a second while the spider makes a capture, but always part of the body is kept in the opening of the nest to prevent the trapdoor from snapping shut (see text, page 195).



A JACK-IN-THE-BOX SPIDER POUNCES ON HER PREY

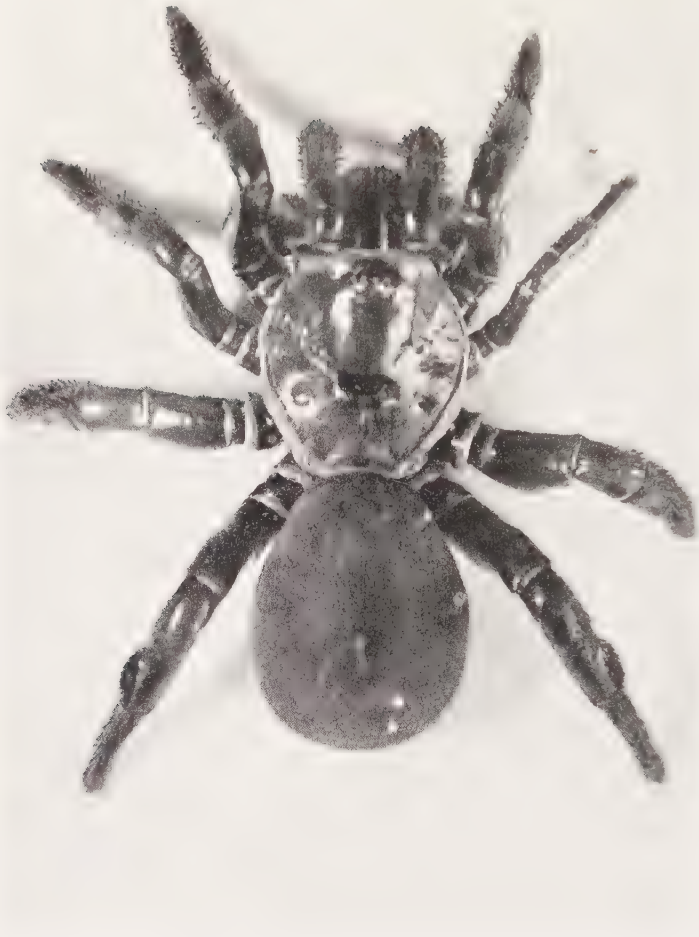
The spider has just pushed back her cork-type lid and is about to sink her poison fangs into an unfortunate sow bug. The camera has caught the split-second action of a trapdoor spider feeding (see text, page 195, and illustration, opposite page).



Photographs © Lee Passmore

SHE DROPS BACK INTO HER NEST WITH A VICTIM

Part of the captured sow bug protrudes above the spider. All eight of the appendages or legs radiating from the spider's cephalothorax and two of the breathing sacs on the abdomen are visible in this remarkable flash-light photograph.



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A SPIDER AMAZON GROWS A NEW LEG

Only the lower animals are capable of replacing lost limbs, and the trapdoor spider is one. Her new leg, second on the right side, is almost fully developed (see text, page 210).

Once when we were digging out a female nest we noticed a peculiar little heap of loose earth close to the door. Curious, we dug carefully around the burrow and, upon reaching a depth of three inches, we lifted out an entire tube. It proved to be a male trapdoor spider's nest, the first we had found in ten years' search (see page 203).

Except for an adult specimen presented to us by the O'Rourke Institute of San Diego, the little male is the only living male trapdoor spider we ever saw. We offer our observation here only as an opinion based on our discovery, and do not make a positive claim that all male spiders build nests.

At home, we laid our captive on some earth in a box and placed over him a small glass jar, covered with a black envelope to keep out the light.

The following morning we discovered our little male spider had burrowed. Above his tube was a heap of loose earth similar to that we had seen in the field.

Two months later we opened one side of his box and found the little fellow alive and extremely active, running up and down a burrow not more than a quarter of an inch wide and three inches deep.

It appears from our evidence that the male trapdoor spider builds a nest entirely different in its surface appearance from that of the female. This nest had no hinged door.

The female spiders seldom raise their doors in the daytime, unless the light is subdued or they are extremely hungry. We can occasionally tempt them out by imitating the tread of insects crawling near the nests, but they quickly detect the deceit and refuse to leap more than once or twice.

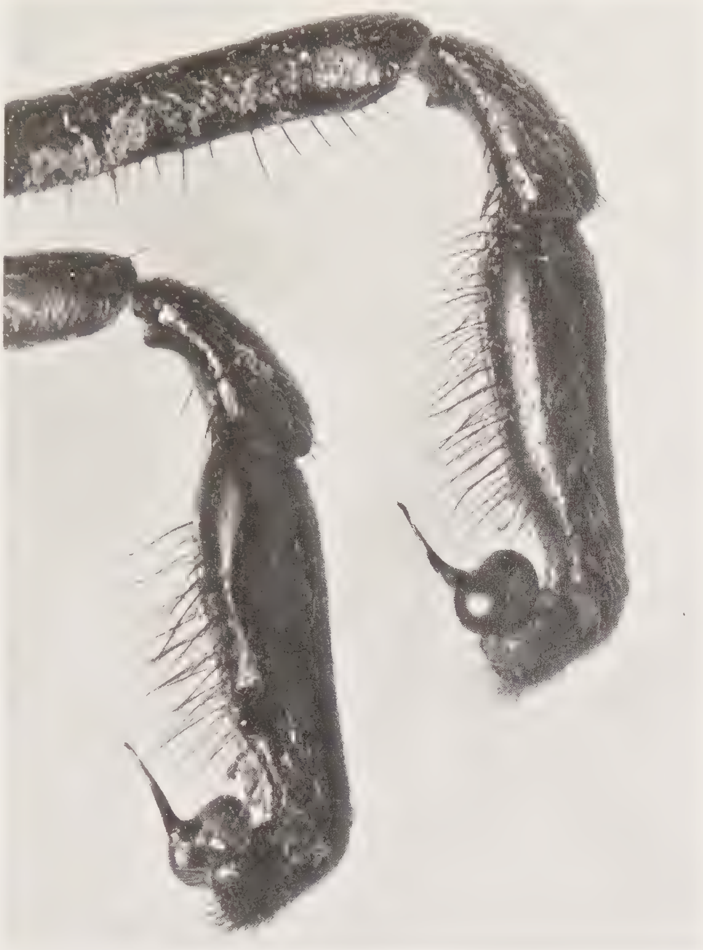
HOW A SPIDER BUILDS ITS TRAPDOOR NEST

In order to make a series of photographs showing how the trapdoor spider builds her nest and fits it with a water-tight, cork-type door, we filled a small box with adobe soil covered with growing moss, and put upon it, in an upright position, two inches of the door end of a spider's nest containing the female.

After several hours of patient waiting, the spider raised her door and brought some moss, which she dropped over the side of the standing tube. She repeated this maneuver until all the moss had been cleared from the bottom of the tube.

Next, particles of earth were brought to the opening and flicked to a considerable distance with her feelers, or palpi. Upon lifting the door occasionally and peering into the tube, we could see her as she labored digging out the soil. Deeper and deeper she excavated, presently disappearing in the new burrow.

In the morning we removed the old nest and exposed the new one, but the spider by this time was down in the ground, entirely out of sight. To keep out the light during the day, we placed a tin box over this opening.



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THE CLAWLIKE FEELERS OF THE MALE TRAPDOOR SPIDER

Only the first three joints of the feelers appear, greatly enlarged. When the eggs are fertilized, the bulblike organs with sharp claws lift the covers of the sacs, exposing the eggs, and permit the semen to enter.

Soon after dark she again began to bring up more earth and make preparations to build a trapdoor to her new nest. She manipulated her sharp fangs as picks, smoothing the edges of the opening and trimming away all roughness. Then she brought damp soil from the bottom and applied it to the side of the entrance, packing it down solidly with her fangs and mandibles.

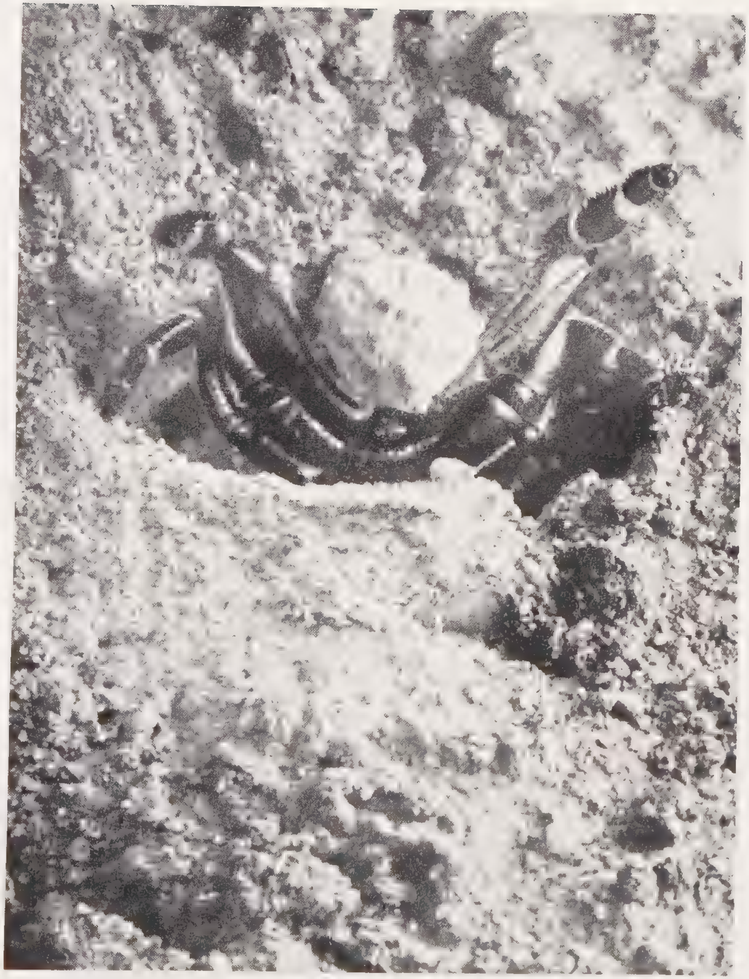
After adding fresh earth each time, she would turn around, bring her spinnerets into position, and with graceful movements weave a trail of silky webbing. She continued this process until the cover extended a third of the way across the opening (see page 209).

At this point we began to wonder how the little worker would manufacture a hinge for her front door, but she soon solved this problem in simple fashion. She raised the partly made door and bent it back to a vertical position. Naturally, it cracked in a straight line near the edge of the opening, but the flexible, reinforced webbing prevented separation from the side of the burrow. The fastening thus made was a hinge of amazing strength and durability.

WORKS WHILE HOLDING THE DOOR

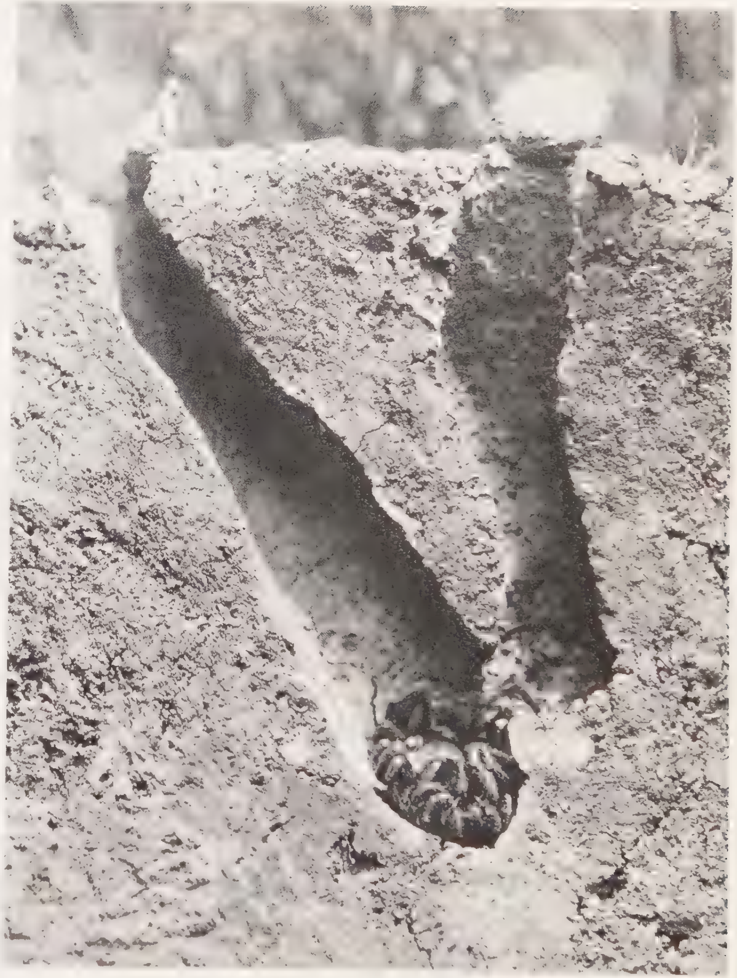
Holding the door in a vertical position, she continued alternately to add earth and webbing to the outer edges until the door was completed.

Frequently during construction the spider would pull up tiny bunches of moss and plant it on the top of her door, carefully



SHE HURLS A STONE HEAVIER THAN HER OWN WEIGHT

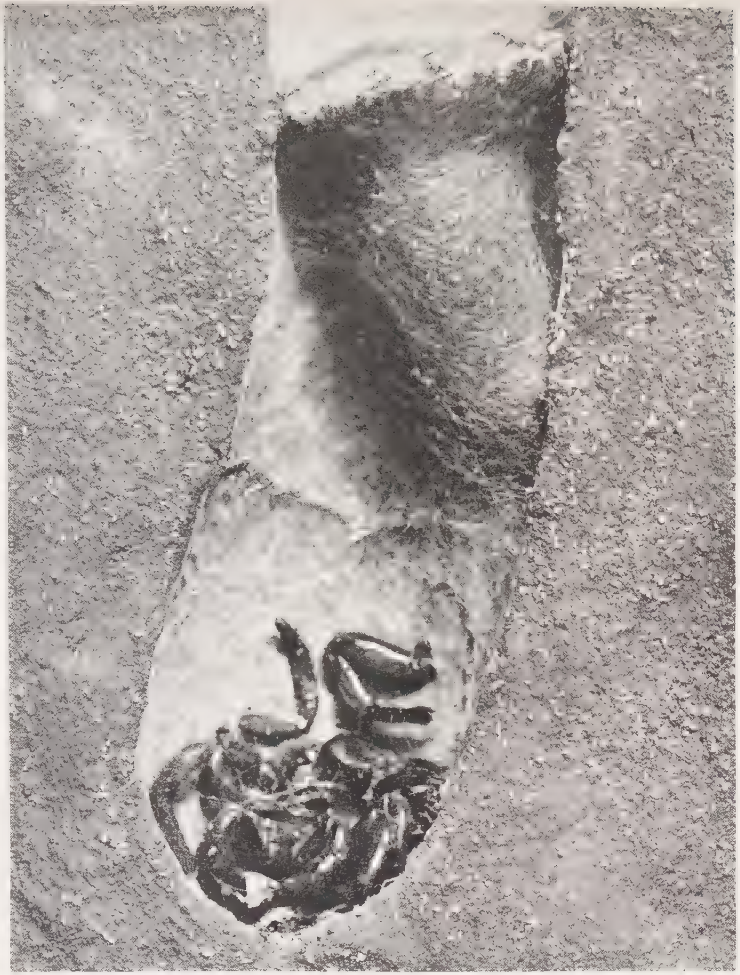
The spider shown in the photograph is bringing a large stone to the surface, holding it with her feelers. She seemed to have little difficulty.



Photographs © Lee Passmore

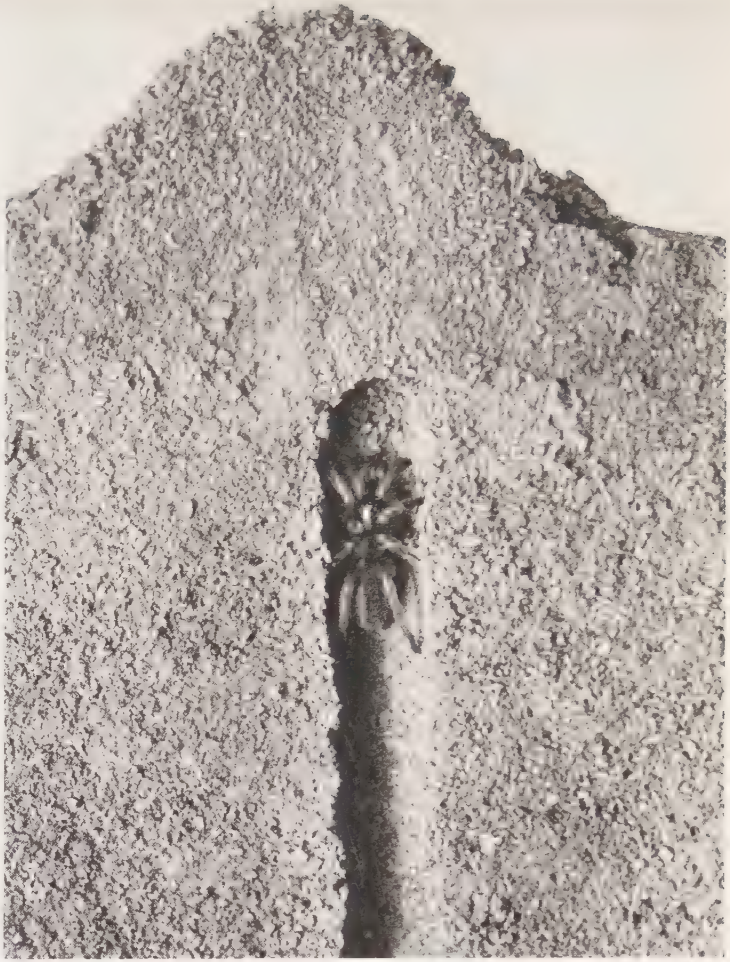
TRAGEDY ENTERS THE BURROWS

A trapdoor spider will never allow another to enter her nest, and when two meet while excavating they fight until death.



THE SPIDER BECOMES A VICTIM OF HER GUEST

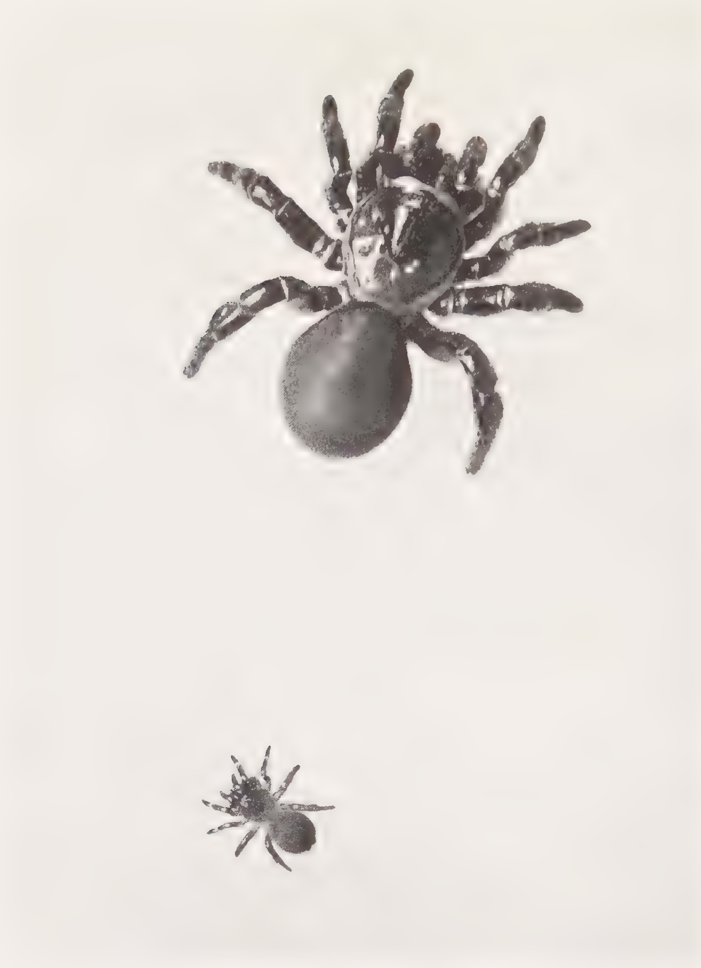
The skeleton which lies at the bottom of the burrow is all that is left of the spider after a wasp larva has fed on its tissues (see illustration, page 211). The cocoon above was spun by the grub, which later will break its way out as a perfect spider wasp like its parent. Then, emerging from the burrow, the fledgling wasp flies away to look for a mate and another spider host to repeat the cycle.



Photographs © Lee Passmore

A MALE TRAPDOOR SPIDER IN ITS PECULIAR BURROW

After years of search, this little fellow, uncovered accidentally, was the only male spider found by the author and his friend, Mr. F. E. Beck. They believe that the male builds a little heap of earth over his nest instead of the usual door. On three different occasions this male built a burrow exactly like the one in the photograph (see page 197). The male is considerably smaller than the female.



© Lee Passmore

LIKE MOTHER, LIKE DAUGHTER

The small spider, about a year old, built a tiny nest only a few inches away from that of its parent and exactly like it in every detail. As she becomes larger, she will tear the walls away, enlarge the opening, and construct a new burrow. The figures are slightly enlarged.

sticking the roots into the earth as an expert gardener might do. To-day the moss is growing over the entire surface of the door and the nest is well camouflaged (see illustration, page 198)

While surfacing the under side of her door with webbing, the spider continued the process down into the tube and applied a fine silky lining to the walls of her nest. It was beautifully finished from the top to the bottom with a lustrous coating as smooth as paint.

Next, the spider pressed her two sharp fangs deep into the soft earth on the under side of the door near the outer edge. She did this several times, until she seemed satisfied with the holes, or "eyebolts."

Then, inserting her fangs again, she pulled the door shut in a succession of violent jerks. By degrees the door was drawn into the tube; and since both surfaces were soft and pliable, they soon fitted together as perfectly as a compression valve, making the nest watertight. This last operation completed the nest. The building had consumed about sixteen hours of actual working time.

Her work finished, the little creature closed her door and no doubt found a safe and comfortable place at the bottom of her new burrow where she could rest from her labors.

SEVENTEEN MONTHS WITH NO FOOD

We tried to lift the door next day, but found the spider was on the job. She had a good grip on the lid with her fangs.

Later, we obtained a photograph of this spider capturing a sow bug, the first victim to be caught from the new nest (see illustration, page 199).

Trapdoor spiders sometimes hibernate, but at no given period or season, as does the true hibernating animal. We have found on numerous occasions the nests of the spiders tightly sealed with earth just below the doors. One specimen was kept under observation for more than 17 months, the spider living in self-imposed solitary confinement during that time, with no way of procuring food. At the end of her hibernation she removed the seal and appeared fresh and clean. She had shed her outer skin.

The mother spider seals the door also when she is about to lay her eggs, for she must not be disturbed at this time. Sometimes seals are made of thin web, stretched tightly across the opening.

This we thought at first was for the purpose of keeping the young spiders in the nest, but we had to abandon the theory when we found webless nests containing young spiders. The latter seem to enjoy the warmth of the sun, for often during the day they cluster around the opening just below the door and retreat to the bottom of the tube only when the surface of the earth becomes cooler with the approach of night.

THE VICTIM BECOMES THE KILLER

We have never found young spiders in the nests of females which have been held in captivity for more than one year. To the contrary, all nests brought from the hills unbroken and containing eggs produced the usual two or three hundred young spiders.

When extreme hunger causes the spider to capture her prey in the daytime (and this often occurs), she is attracted to her door by the vibration of any insect that walks over the ground near her nest. She may even mistake for the usual sow bug a spider wasp (*Pepsis mildei*), her most deadly enemy, which, alighting by her door, she recognizes too late (see page 211).

In the struggle the wasp stings and paralyzes the spider, rendering her entirely defenseless. The door to the nest being open, the wasp enters the burrow, dragging its helpless victim to the bottom, and deposits an egg in or on the living spider.

The grub, when hatched, burrows into the body of its host and feeds on its tissues, but does not attack such vital organs as the heart. The spider lives with the grub within it, usually until nearly time for the latter's pupation. The grub then spins a silken cocoon around itself. Later it breaks its way out and appears in the form of a perfect spider wasp, which after mating finds another spider host to repeat the cycle (see illustration, page 203).

When death comes to the owner of a nest, no other trapdoor spider will take possession.

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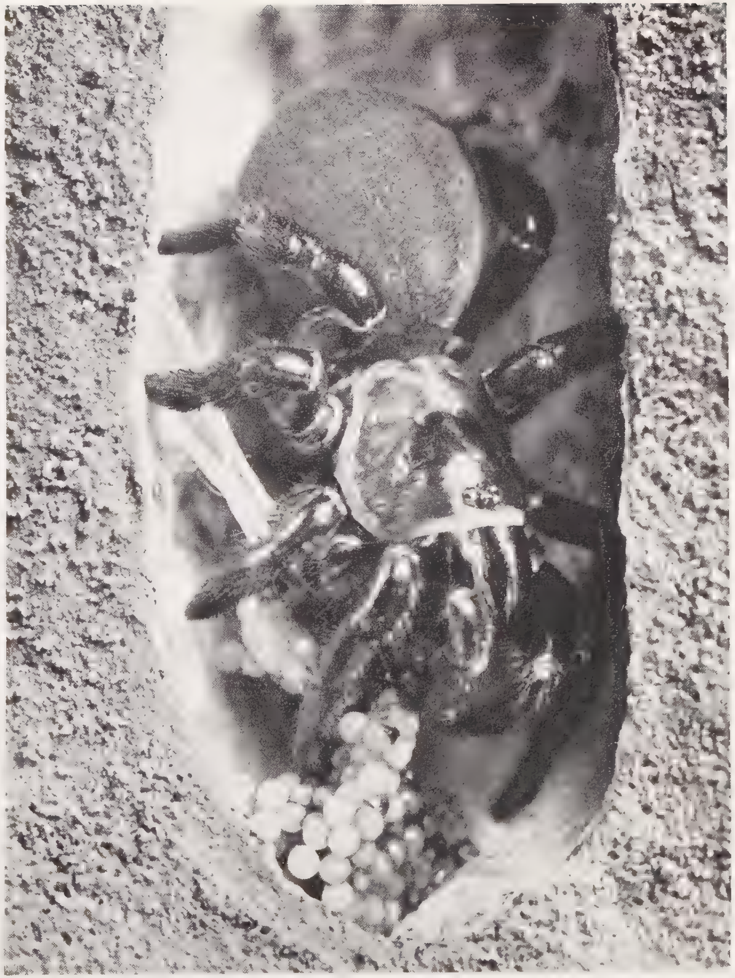
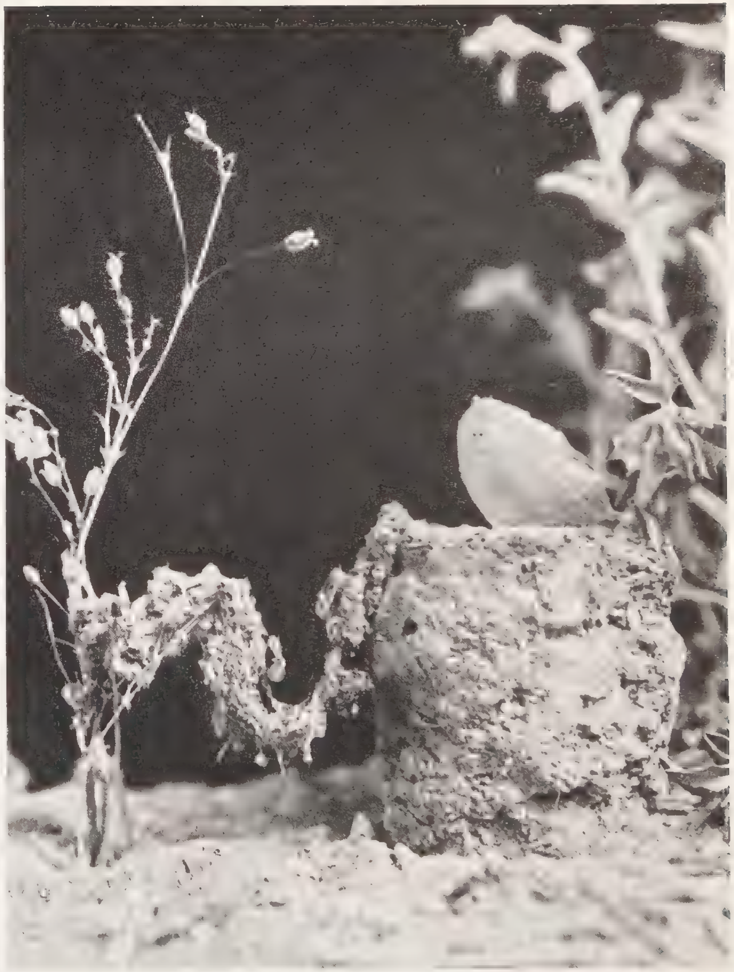
TRAPDOOR SPIDERS ARE HIS HOBBY

For more than ten years the author and Mr. F. E. Beck, who allows his charges to crawl over him, have been gathering these peculiar spiders and studying their solitary habits. Trapdoor spiders still remain among the least-known creatures of the animal world.



SHE EATS HER OWN INFERTILE EGGS

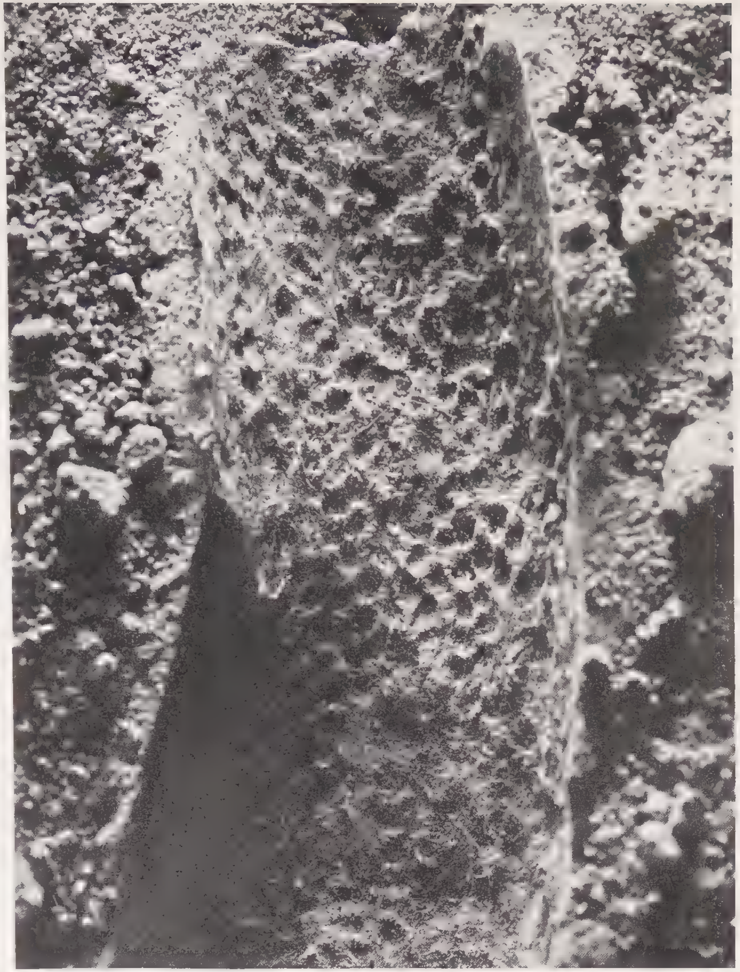
In a little more than an hour the spider devoured about 300 eggs. When she had finished her repast, the spider appeared no larger than she did before commencing, even though the egg mass was the size of her abdomen. About half of the uneaten eggs had fallen from the sac and lay at the bottom of the burrow when this photograph was made.



Photographs © Lee Passmore

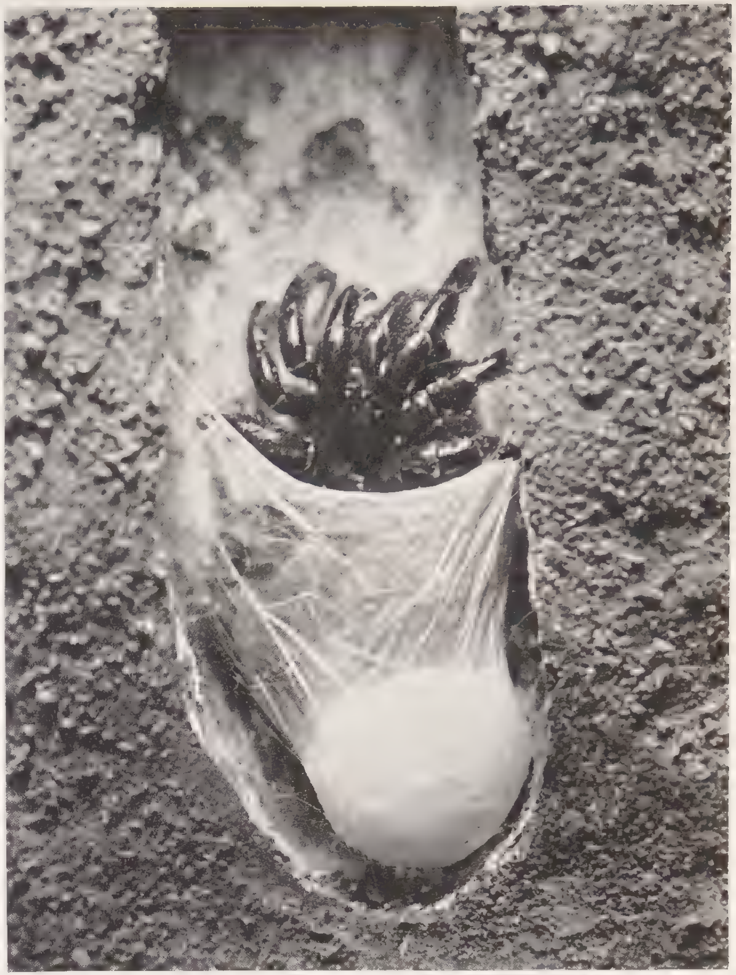
THE SPIDER USES WEBBING AS A CONVEYOR BELT

When the female spider is excavating, instead of carrying small bits of earth to the surface one at a time, she spins sticky webbing over the mass, making the earth cling to the web by stirring it about. Then she pulls the webbing to the surface as a sailor would pull a coil of rope from the hold of a ship.



INDENTATIONS MADE BY A SPIDER'S FANGS ARE HARD

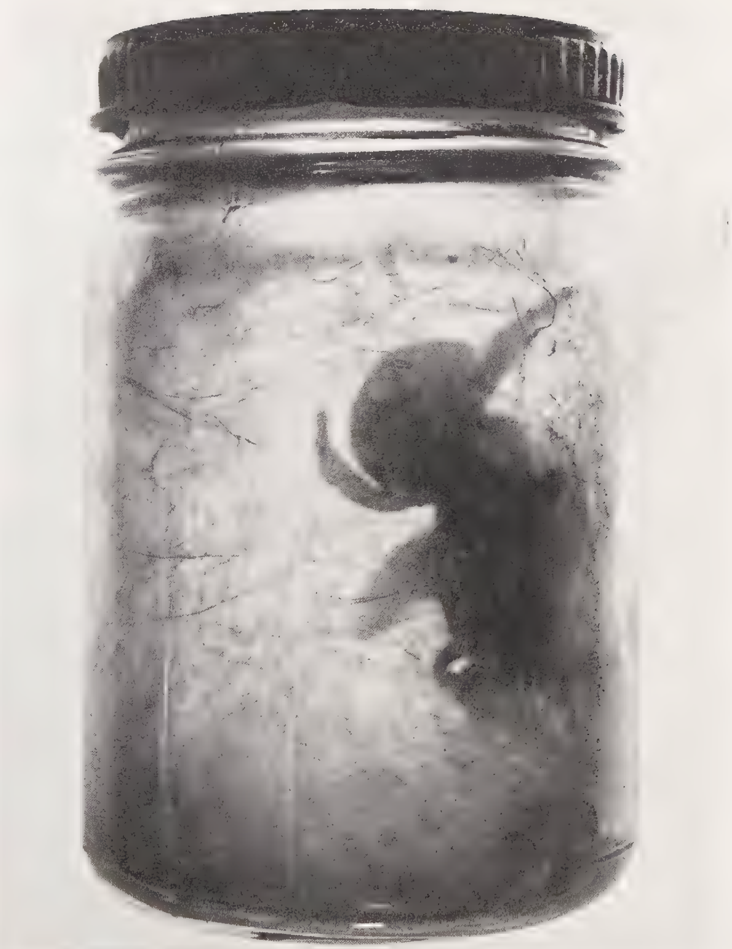
After the spider has completed the excavation of her burrow, she invariably tamps the walls with her fangs, to keep the earth from crumbling in. Silk webbing is then applied as smooth as paint (see page 200).



Photographs © Lee Passmore

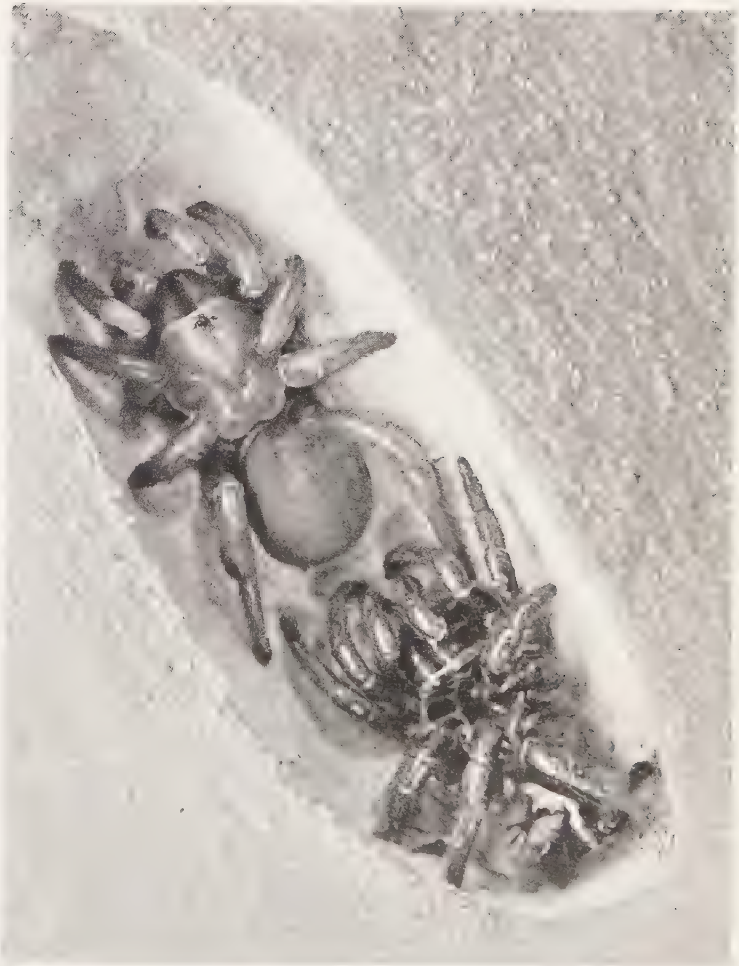
THE MOTHER STAYS CLOSE TO HER EGGS

When the spiderlings are hatched and ready to leave the sac, the mother makes an opening through which they emerge, to swarm over her body and around the walls of the nest. The door is usually sealed during incubation.



A TRAPDOOR SPIDER LINES A JAR WITH A FILMY WEB

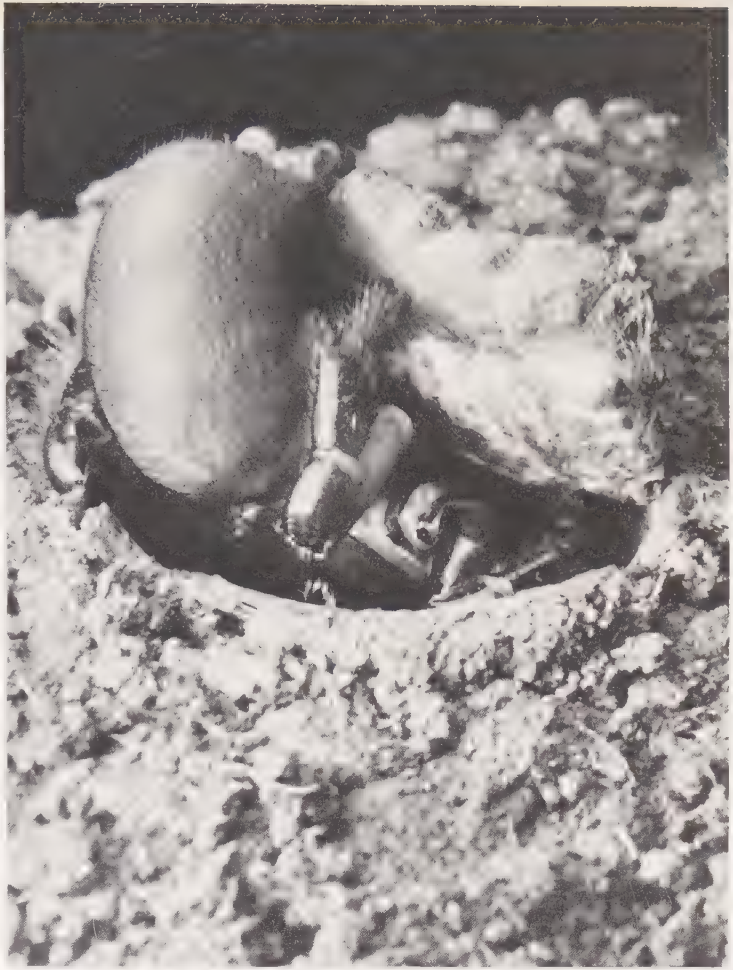
Placed in the jar on a dark shelf and forgotten, this lady spider tried to make a nest out of her temporary home. When found, the jar looked as if it contained milk, for web lining covered the walls but not the top.



Photographs © Lee Passmore

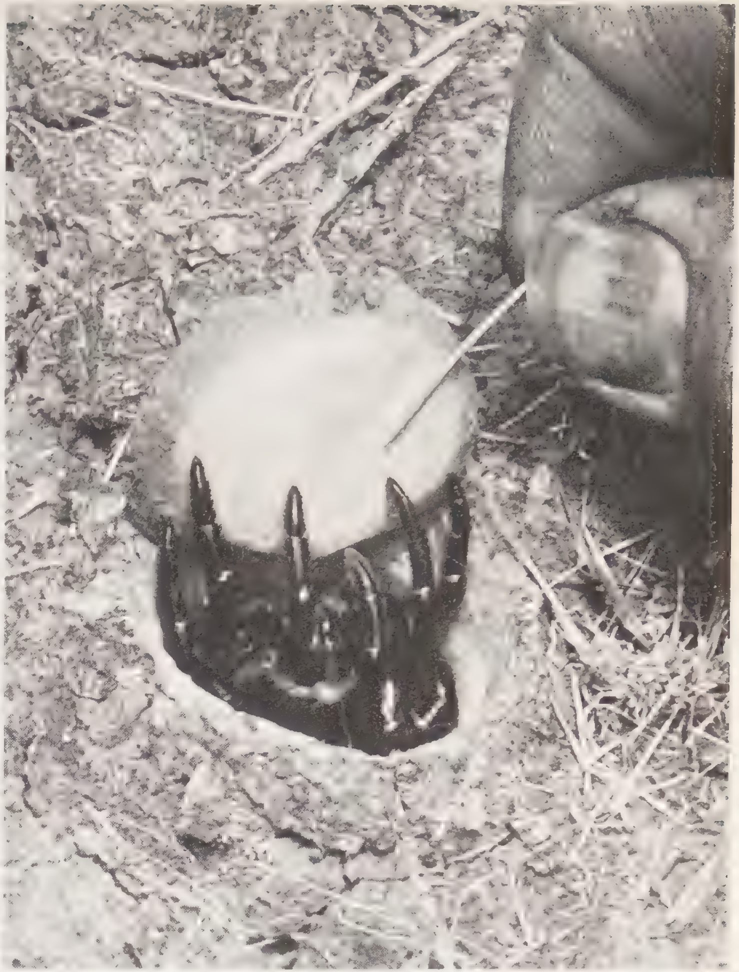
NOT TWO SPIDERS—BUT ONE AND A DISCARDED SKIN

This spider, having shed only two days before, was too weak to move, and had to be lifted into the position shown in the photograph. Trapdoor spiders (see page 210) begin to shed when they are about two months old.



A SPIDER BUILDS A TRAPDOOR

Holding the door vertical and standing on her head, the spider has brought her spinnerets into position and is applying a spray of web over the edges and the under surface. Damp earth is used for reinforcing, especially in that part where the hinge is located (see page 201).



Photographs © Lee Passmore

A PIN IS NOT ENOUGH WHEN SHE CLINGS WITH HER FANGS

Usually, when the door is shut, the spider grips with her fangs the two small holes near the top of the lid and braces her legs against the walls of the nest. A knife blade bends when attempts are made to pry open the door (see page 210).

Spiders, like snakes, are the object of man's instinctive fear, and the first impulse of the average person upon encountering either is to destroy them. With few exceptions, however, spiders are harmless and will not bite if left undisturbed. The venom of a trapdoor spider acts very quickly on small insects, but it is not considered dangerous to a human.

Since they are all carnivorous creatures and maintain themselves by preying upon insects which are real pests, the spider is far more beneficial than harmful to man.

SPIDERS ARE HELPLESS WHEN THEY SHED

The most critical periods in the life of a trapdoor spider occur when it is shedding. The hard, non-living, shell-like outer skin, becoming too small for the growing spider, is cast off.

The trapdoor spiders usually shed in July, August, and September—that is, before the rainy season. In preparation for this period, they fortify their nests to guard against possible intrusion. Seals of well-packed earth placed just below the lid fill the entrance completely.

Once, when we were watching a transplanted spider building her new nest (see page 208), we noticed that she had stopped digging for no apparent reason. Upon investigating, we found our spider was shedding.

First, the shell-like upper surface of the cephalothorax, or anterior portion of the body, separated from the lower part and the skin covering the abdomen shriveled and peeled off. Then the body of the spider appeared, heaving and pulling as she endeavored to withdraw her tender limbs from their outgrown coverings.

It required more than an hour for the spider to separate herself from the cuticle, and she remained motionless for some time after emerging, completely overcome with the exertion. She seemed to have no control of her legs.

Standing beside her was the old casing, so little disturbed that it might easily have been mistaken for another spider. The betraying characteristic of the empty shell was the abdominal portion, which was not so prominent as that of the living spider.

The spider herself resembled an almost transparent wax model, reflecting light like a piece of glass. Even the fangs were white and the mandibles quite colorless. The only parts which showed any color were the eyes, the abdomen, and the coarse hair that sparsely covered her appendages.

Three hours later the spider became darker, first a pale blue and then a greenish blue. Within two days she was quite dark. On the third day she died, presumably from exposure to the open air and light.

Occasionally we uncovered evidence of the resourcefulness of the trapdoor spider in times of emergency, such as when her home is destroyed.

When a nest is built in soft gray adobe, the hot summer sun causes the earth to crack in deep crevices around it. A heavy rainfall fills these cracks and sometimes washes away the walls of the burrow. Soon the nest fills with the loosened soil and the once cozy home with silk-lined walls is ruined.

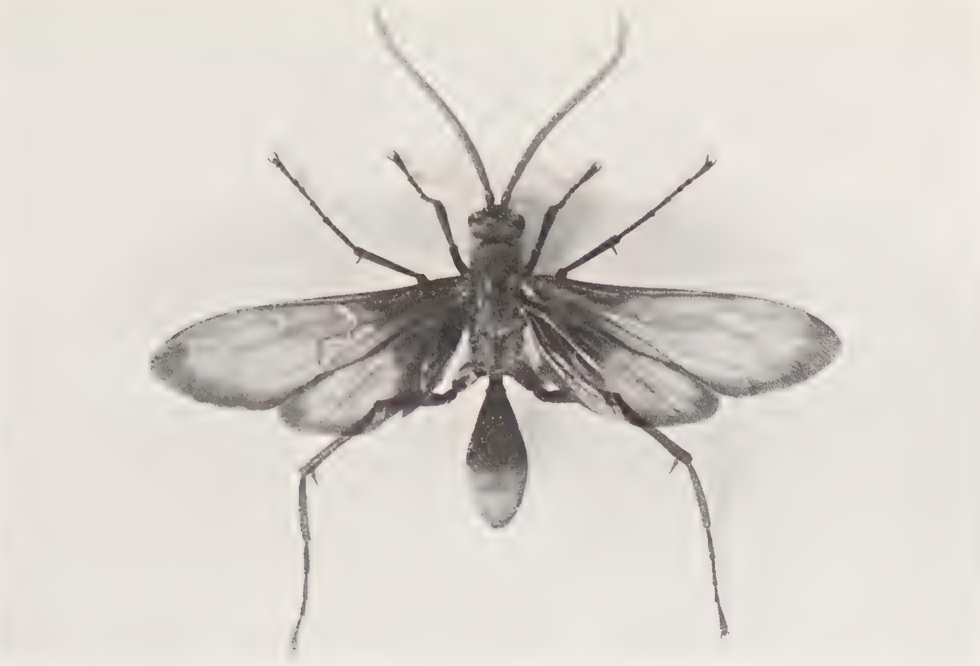
During the deluge the spider seeks shelter beneath her door, where she remains in safety until the storm is over.

If the door and beveled edges to the opening remain in good order, she rebuilds the damaged home alongside the original. It often happens that a spider completes her new nest just as another rainstorm comes, and she must go through the whole process again. We found one nest that had been rebuilt six times, the burrows being located side by side and all under the same trapdoor.

In contrast to her size and weight, the strength of the trapdoor spider is remarkable. She is capable of resisting a lift which we estimated at 10 pounds or more on her door. We came to this conclusion by the force we had to exert when prying upon the door with a strong knife blade. It would bend almost to the breaking point. Sometimes the web lining near the top of the burrow bears witness to her struggles to retain a hold, and the rims of the holes in the door are torn out by the pull of her fangs (see page 209).

SPIDERS MAY REPLACE LOST LIMBS

Only members of the lower orders of animals are able to reproduce lost limbs. The trapdoor spider has this peculiar power. However, we have found only one spider, among the thousands which have come under our observation, that bore evidence of having grown a new leg. This particular specimen was full-grown, and except for the dwarfed size of the second leg



© Lee Passmore

THE SPIDER WASP IS A TREACHEROUS ENEMY

Sometimes the female spider captures its prey in the daytime and instead of a harmless sow bug finds herself in deadly combat with this wasp. Usually she is stung and paralyzed by the wasp, which then carries her down into the burrow. The wasp then lays an egg in or on the spider's body. Later the egg hatches into a grub, which burrows about in the spider and eventually destroys it (see text, page 205, and illustration, page 203).

on the right side, it was normal. The spider favored this smaller appendage as it walked. She would raise the small leg off the ground and carry it elevated, occasionally putting it down gently, as if it were causing her pain (see illustration, page 200).

How she lost her leg we do not know, but we believe perhaps a bird caught and tore it away from the body before the spider scuttled into the sanctuary of her burrow.

There is a remarkable difference between the palpi, or feelers, of the male and those of the female (see illustration, page 201). The female's feelers, long and strongly built, are used in building her nest. The male's feelers, however, play an important part when the eggs are fertilized.

The small, bulblike organ with a tiny claw extending from it serves to raise the cover of the reproductive organ of the female and expose the eggs for fertilization.

It is our belief that the male spider goes to the entrance of the female's home when mating occurs.

Our study of these solitary creatures continues, and we hope in time to solve many of the problems which as yet remain mysteries to us.

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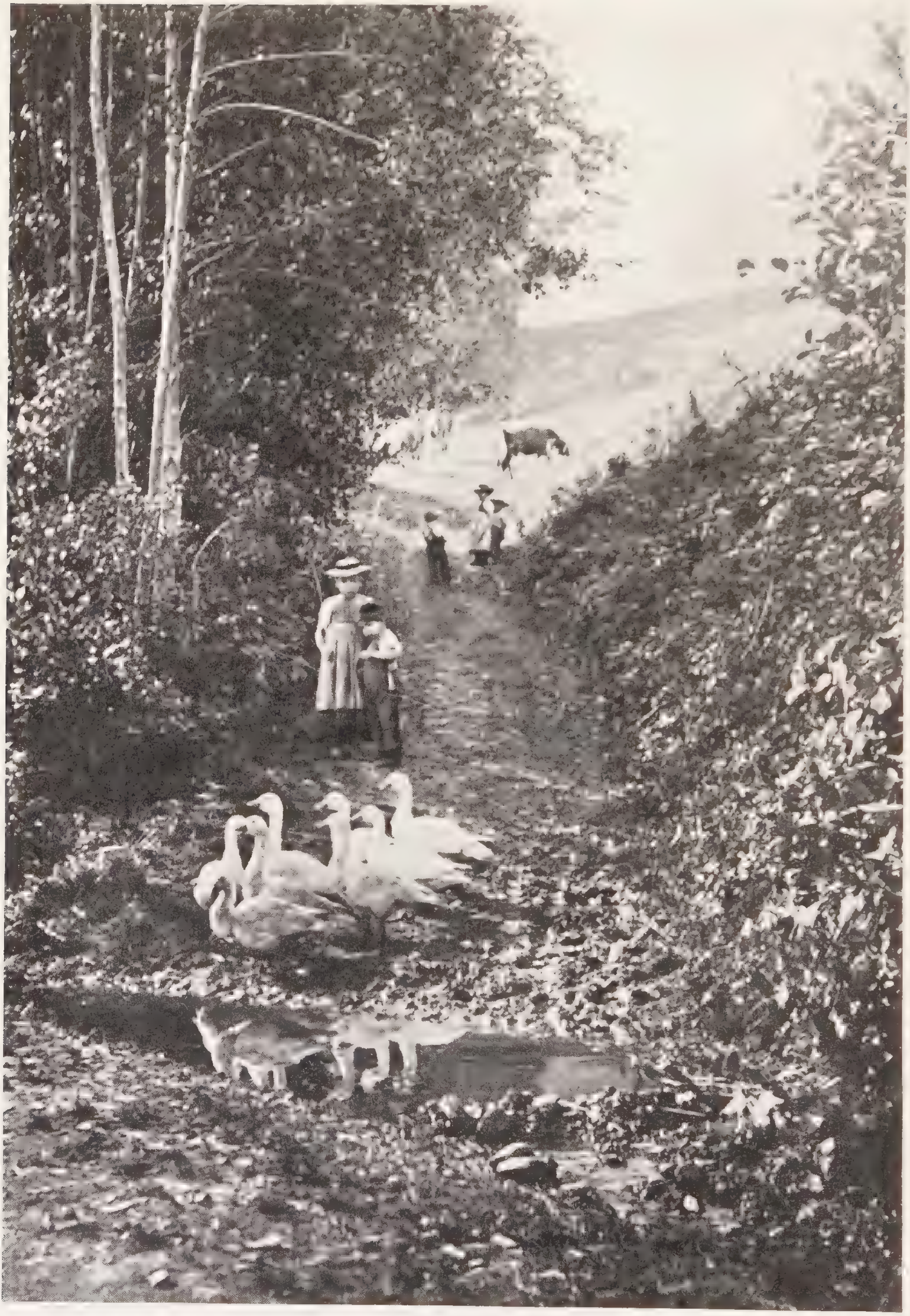

A GOOSE GIRL OF THE BLACK FOREST

She wears a straw hat of a shape worn by her mother and her grandmother before her. Geese raising is as common a household practice in the Black Forest as chicken raising is on many small American farms.

EXPLORING THE WONDERS OF THE INSECT WORLD

By William Joseph Showalter

July, 1929

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EXPLORING THE WONDERS OF THE INSECT WORLD

By William Joseph Showalter

Author of "Exploring the Glories of the Firmament," "Exploring the Mysteries of Plant Life," etc., etc., in the National Geographic Magazine

Though intrepid explorers have conquered the earth's opposite poles, climbed its highest mountains, crossed its most dangerous deserts, penetrated its deepest jungles, and sounded its most profound seas, fortunately they have left many realms closer home and less challenging to human endurance where the humblest of us can lead expeditions and from which the poorest of us may bring back rich trophies of new knowledge.

Insectdom is one of these near-by realms that offers rare rewards to those whose eyes are alert, whose minds are keen, and whose patience is unrelenting. It begins in our own dooryards and stretches as far afield as we choose to wander. The man, or woman, or child who turns explorer there will find among its tiny folk more occasions to marvel than Gulliver in all his travels, more reasons to wonder than the fabled adventurer into the topsy-turvy territories of the Kosekins.

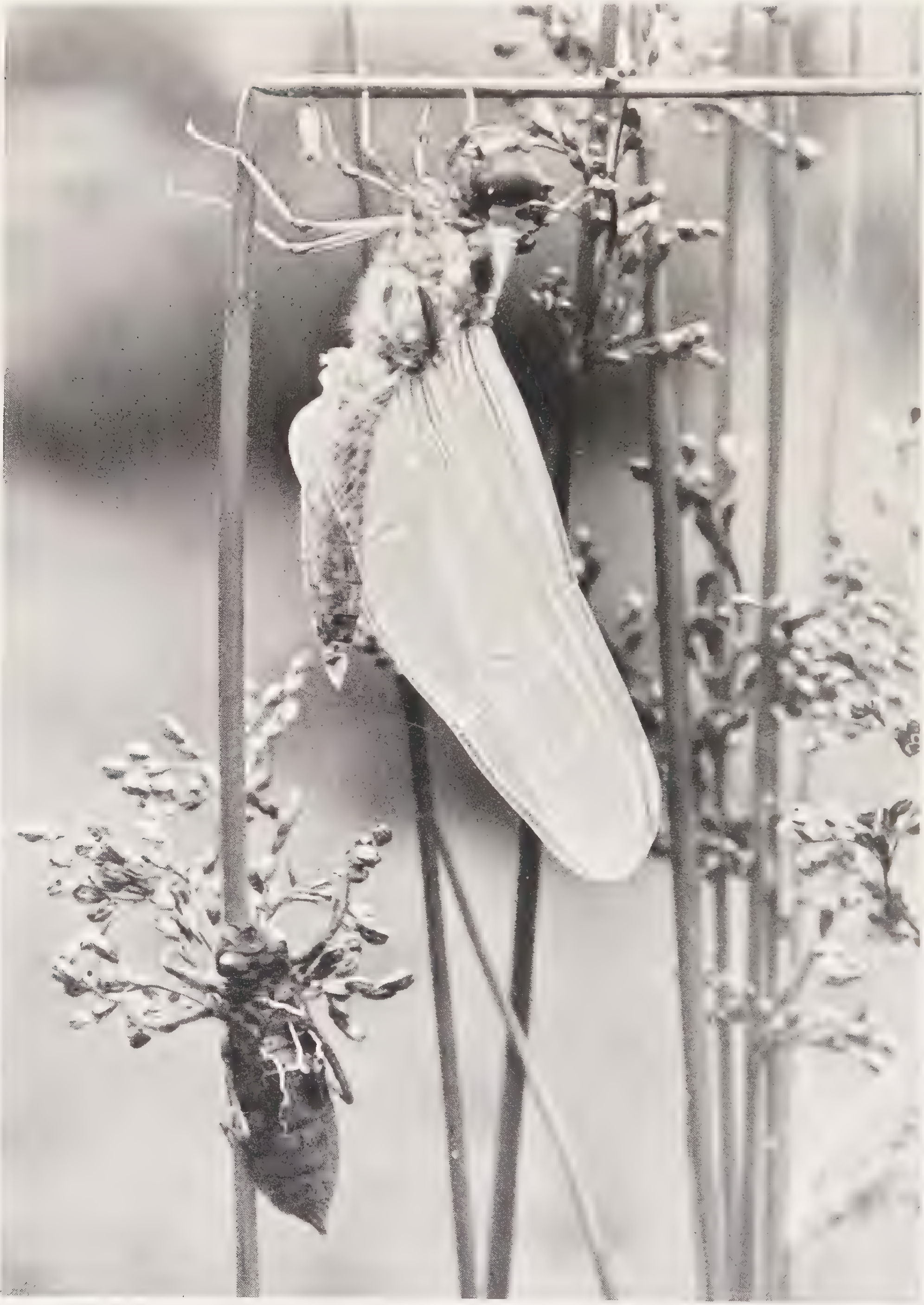
For among the insects one finds habits of life that run the gamut of interest, from the amazing to the bizarre; discovers traits that in some ways seem to transcend human intelligence; beholds untaught powers of foresight that appear to outshine man's most highly trained faculty of taking thought of the future; sees intricate chemical and physical problems solved in a manner worthy of our finest laboratories; gets glimpses of natural powers of perception that go far beyond our unaided senses and rival the detecting powers of the finest instruments that science has brought to the student's aid. One even runs upon solutions of involved social problems that civilization has tried vainly to master.

INSECT FORERUNNERS OF MODERN INVENTORS

Into this wonder world many explorers have gone who could match the intrepid courage of a pole-seeker with the unconquerable patience of a life-history hunter. Whoever reads Fabre and Forel, Comstock and Kellogg, Lutz and Wheeler, the Peckhams and the Raus, and scores of others knows alike what infinite treasures of truth already have been gathered and what bonanzas of interest still lie untouched.

Through such workers as these we have learned that long before our ancestors had emerged from their primeval caves, or had dreamed of a better anesthetic than a club, the glowworm had evolved a sleeping potion so subtle that its victim could not perceive its administration, yet so powerful that nothing could disturb the profound sleep it induced.

When our forbears were dressing in skins and before they had domesticated even the dog, the bagworms, larvæ of the Psyche moths, were tailoring themselves snug coats and close-fitting nightcaps,



© Lynwood M. Chace

A DRAGON-FLY THAT HAS JUST EMERGED FROM ITS NYMPHAL STAGE

This gauzy-winged creature has just transformed itself from a nymph, such as is shown in the lower left corner of the picture. It will cling to the grass stem until the chitin of its body hardens and until the fluid that flows through the hollows of the struts forming the framework of its wings crystallizes. Then it will be ready to fly away, one of the swiftest of all the insect clan.

while the ants were keeping "cows" and growing "mushrooms" (pages 16, 17).

Before primeval man had learned to kindle his first fire or dreamed of the use of coal, the social bees were employing in hive ventilation the identical principles that industry now uses in keeping pure air in modern coal mines.

While our race was still without the slightest understanding of the functions of the nervous system, some of the wasps had learned to paralyze their prey and to classify insects according to the unity or multiplicity of their ganglia.

Far antedating man's earliest employment of the principles of cold storage and sterile preserving, the wasp was keeping meat fresh for weeks and the bee was storing honey that remained sweet indefinitely.

Long before modern civilization had appeared upon the face of the earth, the caddis-fly's children were building themselves submarines and some species were attacking their victims without warning.

The Eumenes wasp was a finished potter, employing fine natural cements and excellent hydraulic mortars, ten thousand generations before the human artisan knew how to fashion a flint.

The bombardier beetle employed gas against his enemy unnumbered centuries before the oriental invented the stinkpot or man resorted to gas warfare.

AMAZING ADAPTATIONS TO ENVIRONMENT

While man has progressed mainly through the development of the intellect, meeting his problems of existence through the powers of his mind, Nature has helped the insect hosts climb their ladder of achievement by developing their physical adaptations to the requirements of their environment.

For vast ages and countless generations it has been the great Master Breeder sternly, even if so slowly as to make it an almost imperceptible process, weeding out the weaklings and protecting the fit. In this way every physical and instinctual quality that has made an insect more suited to its environment has been further improved.

These processes, employed with such profit by man in the development of qualities that the better meet his needs in flowers, fruits, grains, horses, cattle, dogs, and poultry, have wrought marvelous transformations in the insect, both in body structure and life habit.

Through them the wasp has achieved the poisoned dagger with which to paralyze its prey; the bee has mastered the secret of sex control; the wingless springtail has produced a triggerlike, stiff hair that provides it with powers of locomotion; the adult May-flies of some species have done away with mouths and stomachs because their mature lives are too short to need them; the dragon-flies have come to possess eyes with as many as thirty thousand facets, to furnish the intense vision required in capturing darting, fast-flying prey.

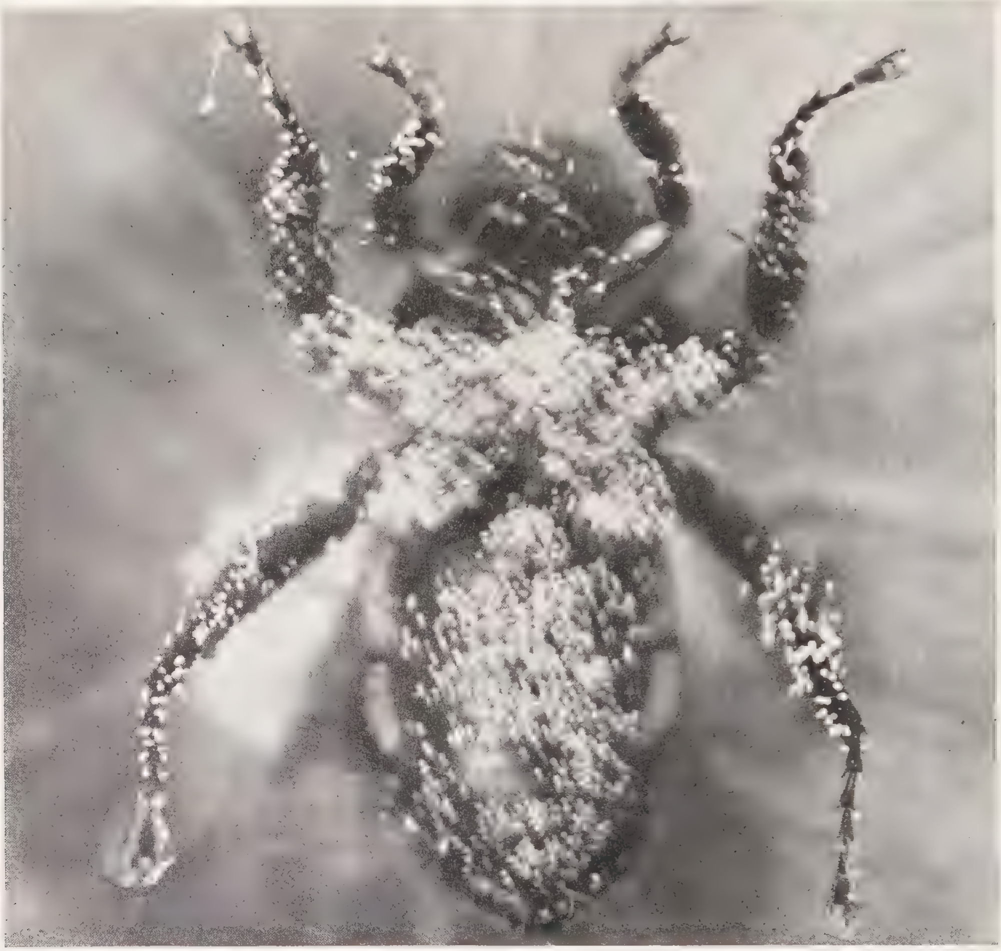
Through these processes, also, the walking sticks have come to look like twigs; butterflies relished by the birds have developed a close resemblance to those the bird's palate detests; certain flies that prefer the precincts of the bumble-bee's nest have copied the bumble-bee's clothes and stature in order to be rated as members of the family rather than as interlopers.

The plant-lice have eliminated males from all but one of their many annual generations, and under laboratory tests have produced 94 generations without the interposition or birth of a single male. The ants bring up heirs apparent to the thrones of their kings and queens, and wood-boring grubs have been known to live forty years in seasoned wood. Carpet-beetles have lived two years in a corked bottle with nothing whatever to eat save the cast-off skins of their own transformations.

THE AGE OF INSECTS

From these fragmentary recitals of some of the ways in which the denizens of the insect world meet their problems of life and solve their enigmas of existence, it is plain that nowhere, either in the fields of fact or fancy, can there be found more surpassing marvels than are to be discovered among the humble folk whom most people dismiss from their minds as mere "bugs."

Man proudly refers to the various epochs of his own history as the Stone



Photograph by Paul Griswold Howes

AN ENLARGED VIEW OF THE UNDER SIDE OF A BUMBLE-BEE, SHOWING HOW POLLEN GRAINS ADHERE TO ITS HAIRS

In visiting the flowers for nectar and pollen out of which to make the paste which it feeds to the larvæ in its nest, the bumble-bee gets a liberal coating of pollen grains. As it passes from flower to flower many of these grains are left on the stigmas, thus fertilizing them. In this way the bumble-bee serves equally well the flowers and the babies of its own household.

Age, the Iron Age, the Age of Electricity, etc.; but, after all, and in terms of epochs immeasurably longer, this is preëminently the Age of Insects. Both in the number of species and of individuals, the insect hosts are the dominant life of the faunal world. As far back as 1907, according to Dr. Frank E. Lutz, more than 384,000 species of them had been described, and the average annual number of new forms found ranges around 6,000. As entomologists penetrate the tropical world more deeply, the annual accretion of new species tends to increase with the passing years.

Estimates of the total number of described and undescribed species range from two to ten millions. Even at the more conservative figure, this would be six times as many as there are of all other animal species combined.

Within a radius represented by a single hour's motor ride, one may find more kinds of insects than there are species of birds in the whole world, and within an hour's walk more kinds than there are species of mammals in all creation.

When the first ambitious creatures of the "bug" world, which bore a rather close

Photograph by Paul Griswold Howes

A SMALL BEE SCRAPES POLLEN FROM ITS FURRY COAT

The coming of such pests as the recently arrived Mediterranean fruit-fly (see pages 10, 11), the European corn-borer, and the Japanese beetle sends shivers of well-founded dread through the American people; but if our bee friends were to leave us *en masse* we would be even more alarmed. Without their pollen-carrying activities most of our flowers and many of our fruits would disappear.

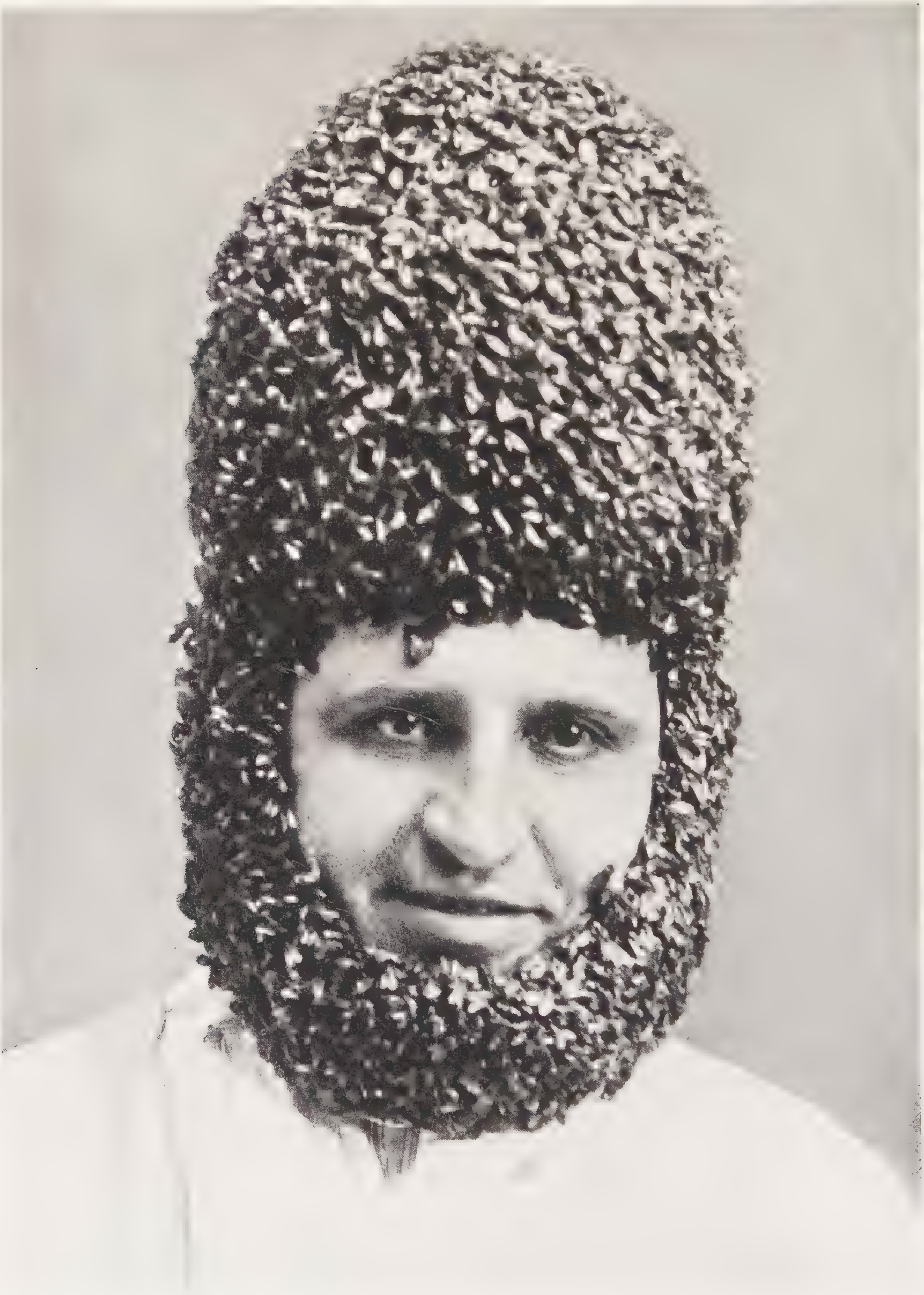
resemblance to our present-day springtails, fish-moths, and silver-fish, began to climb the ladder of winged evolution, releasing themselves from the bondage of feet, they found opportunities for colonization, for multiplication, and for promoting their freedom from enemy attack denied to all creatures limited to legs for locomotion.

AN EONS-LONG STRUGGLE

Chetverikov, the Russian naturalist, describing the trends of early vertebrate and insect life, says that in geological times the vertebrates seemed bent on growing larger, defending themselves in the struggle for survival by accumulating strength. The grass eaters grew larger and stronger, to save themselves from the flesh eaters, and the flesh eaters, in their turn, had to grow stronger and fleeter in order to hold their own in the contest. Finally, both got too big for their environment and both disappeared from the earth, leaving no living species to trace descent from them, and with only their fossil remains persisting to proclaim their one-time existence.

The insects chose another route to survival. With the brevity of life cycle that characterized them, a contest with the vertebrates in size would have been futile; but in smallness they could find a vast number of nooks where they could live in safety, thus filling the chinks and crannies of creation. Just as gravel, then sand and dust, more and more firmly fill the free spaces between the stones in a pile, so the hordes of insects, innumerable as gravel and small as sand, fill the crevices in creation left by the vertebrates.

But even with their smallness the insects of bygone geological ages needed protection. They achieved it by wearing their skeletons on the outside of their bodies and in their wings, and ever since have been growing smaller, although retaining their other major characteristics.



Photograph by Wide World Photos

A HELMET AND CHIN STRAP OF HONEY-BEES

Some strains of honey-bees are mild, sweet-tempered, and gentle; others are nervous, excitable, and cross. Most of them seem instinctively to know who is afraid of them and who is not, and to react to the confidence or fear of those who approach their hives. The Ohio bee-keeper here shown fashioned his dramatic headgear through a gentle and fearless handling of his swarm.

Back in those remote eras when the earth's vast deposits of coal were still living vegetation, the forest swamps were inhabited by cockroaches longer than a man's finger; dragon-flylike creatures with wing spreads of thirty inches pursued the sluggish prey, and ancestors of our May-flies that were as large as a laborer's hand swarmed around at sunset.

Living on the earth long before man came to take his place in the rôle of one having dominion, the insects will, it is freely predicted by many scientists, still remain long after man has ceased to be a mundane tenant. Dr. W. J. Holland, in his classic work on moths, says:

"When the moon shall have faded out from the sky, and the sun shall shine at noonday a dull cherry-red, and the seas shall be frozen over, and the ice-cap shall have crept downward to the Equator from either Pole, and no keels shall cut the waters, nor wheels turn in mills; when all cities shall have long been dead and crumbled into dust, and all life shall be on the very last verge of extinction on this globe; then, on a bit of lichen, growing on the bald rocks beside the eternal snows of Panama, shall be seated a tiny insect, preening its antennæ in the glow of the worn-out sun, representing the sole survival of animal life on this our earth, a melancholy 'bug'."

Photograph by Dorothy Smith

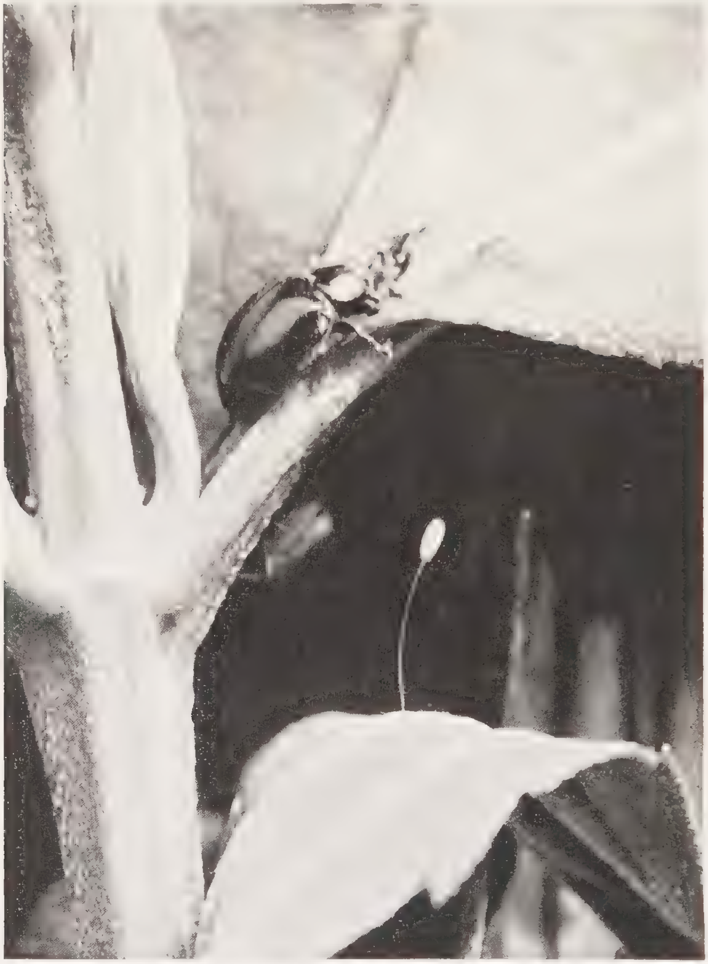
A GOOD-SIZED SWARM OF BEES

By the quality of the food given the female larvæ, worker bees determine whether these shall develop into full-sexed queens or whether their reproductive organs shall be so stunted as to make them practically sexless—fellow-worker bees. So well is the royal bee jelly compounded in the hive that even the beekeeper, feeding it to the larva in the cell, can produce a queen at will (see text, page 11).

Literally true? Certainly not, but a powerful picture of the tenacity of insect life, which was here eons before the first mammal appeared and which probably will be here eons after man's last city shall have been buried beneath the débris of thousands of centuries!

FRIENDS AND FOES OF THE WINGED WORLD

In the furious struggle for survival which is ever raging among the various species of insects, man gains some won-



Photograph by Paul Griswold Howes

A LADY-BIRD BEETLE EATING A PLANT-LOUSE

The plant-lice have eliminated males from all but one of their many annual generations, and under laboratory tests have produced 94 generations without the interposition or birth of a single male (see text, page 3). On the leaf, supported by a hair to keep it out of harm's way, is an egg of a golden-eyed lace-wing fly. The larvæ which emerge from such eggs resemble tiny dragons, and, like the lady-bird beetles and their larvæ, feed upon plant-lice.

derful allies in his own fight for a place in the sun. They prey upon our insect foes as these latter prey upon our food supplies, whether in field or garner, and prevent them from eating us out of house and home.

The Hessian fly, the codling moth, the San José scale, the army cut-worm, the peach-tree borer, the cabbage-caterpillar, the Colorado potato beetle, the Japanese beetle, the Mexican bean beetle, and the apple aphid are only a few examples of the tremendously prolific species that are uninvited and unwelcome "spongers," which insist on being fed before we ourselves can eat.

It is estimated by careful entomologists that only about one per cent of the insect species is directly injurious to man's crops; but these are so greedy and so prolific that the damage they do in the United States alone amounts to more than a billion dollars a year (see illustrations, pages 10 and 11).

The insectean warfare does not end on the battle ground between our enemies and our friends. It is estimated, indeed, that about 50 per cent of all the species are engaged in preying on other insects, including those whose tremendous board bill we have to pay. Watch the wasps provisioning their nests with grasshoppers and caterpillars, or the parasitic flies laying their eggs on cut-worms and in the egg clusters of other enemies; watch the dragon-flies devouring mosquitoes, or the lady-bird beetles combating San José scale, and you will see our faithful friends rendering a vast, even if unconscious, service to humanity.

But the service of our insect friends only begins when they hold our foes in check. Where would be our fruits and our flowers, where our clovers and our vegetables, were it not for the insects that enable them to set seed for our welfare!

Our fruit crops alone are now worth

some $600,000,000 annually. They would be negligible in quantity and value without the winged messengers that carry pollen from blossom to blossom.

CURIOUS QUIRKS OF THE HUMAN APPETITE

Strange as it may seem, insects and their eggs form favorite articles of diet in many parts of the world.

The Moors fry locusts in butter made from camel's milk, the pupæ of silk-worms are eaten in China, and some species of moths are relished in parts of Africa. Several species of beetles are prized articles of food in Turkey, Moldavia, Wallachia, and elsewhere, while in Nyasaland a paste of May-flies and mosquitoes is eaten with gusto. Some tribes of Mexican Indians, by infusing tiger-beetles in alcohol, make a "hooch" that in the amount of "lightning" it possesses excels any U. S. A. brand of home brew.

Photograph by International

PACKING LADY-BIRD BEETLES IN BAGS FOR SHIPMENT

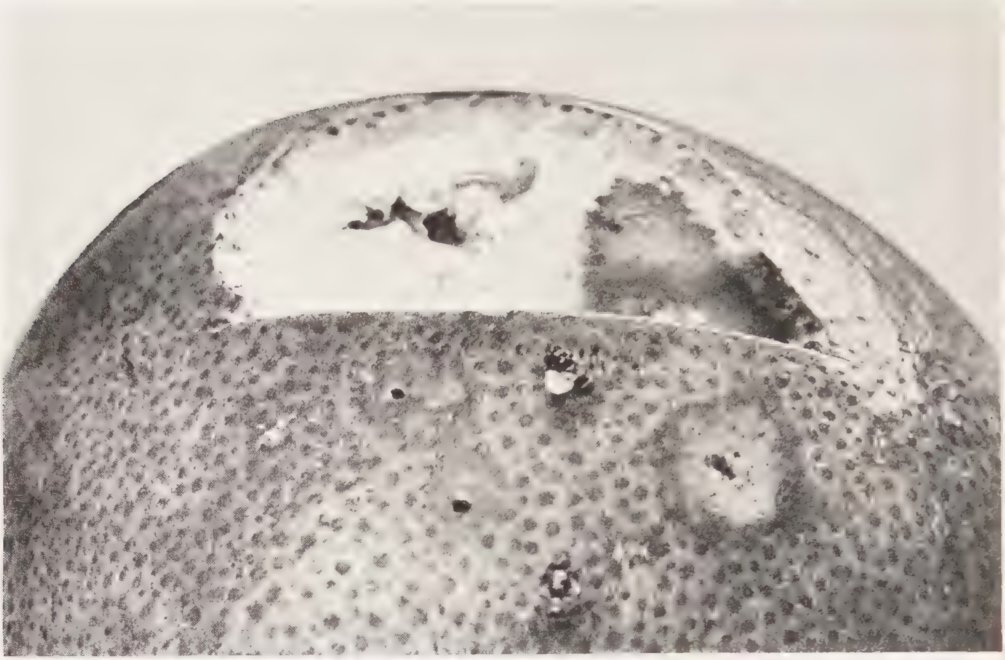
It would be difficult for man to find a better friend among the insects than the lady-bird beetles. They are raised in large quantities and shipped to fruit- and vegetable-growing districts to become allies of man in holding in check scale-insects and plant-lice, which they devour both in larval and adult forms. This shipment is from California.

The insects make important contributions to the world's commerce as well as to regional food supplies. Shellac, which has so many uses, from wax for our floors to stiffening for our derby hats and disk material for our phonographs, is made from lac, the secretion of an Asiatic scale. A beetle known as the Spanish fly is transformed into one of the medical world's principal blistering agents and forms an ingredient of many hair washes.

Tannin and ink are derived from various galls; the cochineal, a scale-insect, is used to make a dye found superior to synthetic dyestuffs for coloring soldiers' uniforms, while the silk-worm is the manufacturer of the world's most prized textile threads, and the bee is maker of one of civilization's most delectable sweets.

THE BODIES OF INSECTS

Some one has remarked that the insects crawl on their backs instead of on their bellies—a statement that is anatomically much more than a half truth. What corresponds in them to our spinal cord lies along the under side of the creatures' bodies; their hearts and stomachs, on the



Photograph courtesy U. S. Department of Agriculture

A GRAPEFRUIT FILLED WITH FRUIT-FLY PUNCTURES AND SHOWING THE MAGGOTS

A single fruit often carries as many as a score of punctures and sometimes as many as a hundred. The maggots are shown in the section from which the rind has been cut away.

other hand, are near the top surface. The skeletons of insects are made up of a series of segments or rings; and, whether in a grasshopper, a dragon-fly, or a moth, in an ant, a house-fly, or a bee, most of these segments are apparent, if examined closely. There are other classes of creatures that have these ringlike segmental skeletons, but to qualify as insects they must have no more than six jointed legs when in their adult form. The "thousand-leggers," the scorpions, the spiders, and the ticks are all cousins, but they are all technically ineligible for membership in the insect "lodge" because they have too many legs.

The circulatory system is amazingly different from our own. In most species the hearts are not complex organs like ours, with divers chambers and sundry valves, but are simple, hollow tubes that contract in waves from end to end. Their blood is not red like ours, but yellowish or greenish. They have no veins or arteries through which the blood moves; rather, it is sent directly through the body cavity, which is filled entirely therewith.

With us, the heart sends the blood to the lungs to be purified and given a new supply of oxygen for its return trip through the capillaries. The insects, having no lungs, get their oxygen, not through the blood, but through little breathing tubes known as tracheæ, which penetrate every part of the body.

FEEDING HABITS OF WIDE RANGE

The feeding habits of this class of creatures are of astounding range. The plant-lice, sucking the sap of rosebush, apple twig, or cucumber vine, love plant juices, just as the mosquito and the flea love animal blood. The honey-bee and the butterfly, drinking the nectar of the flower, are in strange contrast to the sexton beetle and the flesh fly in the quality of their respective appetites.

The wood-borers, satisfied to spend their larval lives eating naught but insipid wood, as they digest their paths through the heart of oak and hickory and elm, have tastes infinitely less spicy than those of the "weevils" that are never so happy as when feasting on Cayenne pepper, or

Photograph courtesy U. S. Department of Agriculture

AN ORANGE GROVE DEVASTATED BY THE MEDITERRANEAN FRUIT-FLY, WHICH HAS RECENTLY MADE ITS FIRST APPEARANCE IN AMERICA

In a bulletin published in 1918 the United States Bureau of Entomology said that there was little danger of the fruit-fly gaining entry through the medium of commercial shipments of fresh fruits. "But quarantine officials have found the pest in fruit concealed by tourists and in mail and express packages sent from infested countries by uninformed persons, and it is by such avenues that the pest is most likely to be introduced." The location of the infested area apparently justifies this prophecy.

of the beetles that know no gustatory joy so satisfying as eating cigarettes.

In the reproductive organs one finds the most startling departures from the orthodox. In evolving their social system, the community-building bees, ants, and wasps have developed highly organized females, which we know as queens, that are marvels of efficiency as egg-laying machines. They mate but once in a lifetime, and therefore have developed a tiny internal pouch in which the male life germs are held.

As they lay their eggs, the honey-bee queens (see Color Plate XII, figure 2) are able, at will, to open or close the orifice of this pouch that leads to the oviduct, and thus to determine whether each egg shall or shall not be impregnated. The ones that are produce females, and those that are not produce males. The queens, it will be seen from this, have come to be masters of the art of sex control.

Then the workers (see Color Plate XII, figure 4) come along with their own development of this art. By the quality of the food they give the female larvæ they determine whether these shall develop into full-sexed queens or whether their reproductive organs shall be so stunted as to make them practically sexless—worker bees. So well is the royal bee jelly compounded in the hive that even the beekeeper, feeding it to the larva in the cell, can produce a queen at will. Yet science never has been able to solve the secret hidden in this queen-making royal jelly.

THE SENSE OF SMELL

In some of the queen-possessing species the neuters will, in the hour of calamity caused by the death of their queen, select one of their own number to function as queen during the interregnum. The larvæ of these, fed the royal jelly, develop into

Photograph by Paul Griswold Howes

A COMMON HORNET STANDS GUARD AT THE ENTRANCE TO ITS NEST

The photographer obtained this picture by building a special scaffold for his camera and using sunlight reflected from a mirror. The hornets and other wasps were the world's first manufacturers of paper. The manner in which they enlarge a little nest smaller than a hen egg into one as large as a half-bushel measure, without disturbing its symmetry or opening up its interior, is a masterpiece in building (see text, page 50).

full-fledged queens, ready to start the colony on its normal course once more.

The sense of smell in some of the insects is almost unbelievably acute. The smelling organs are minute pits or projections on the antennæ and possibly in some of the mouth parts, so arranged as to leave the nerve ends exposed to every odor and at the same time protected from harm. For instance, on a single antenna of an ordinary June beetle there are as many as forty thousand of these olfactory pits.

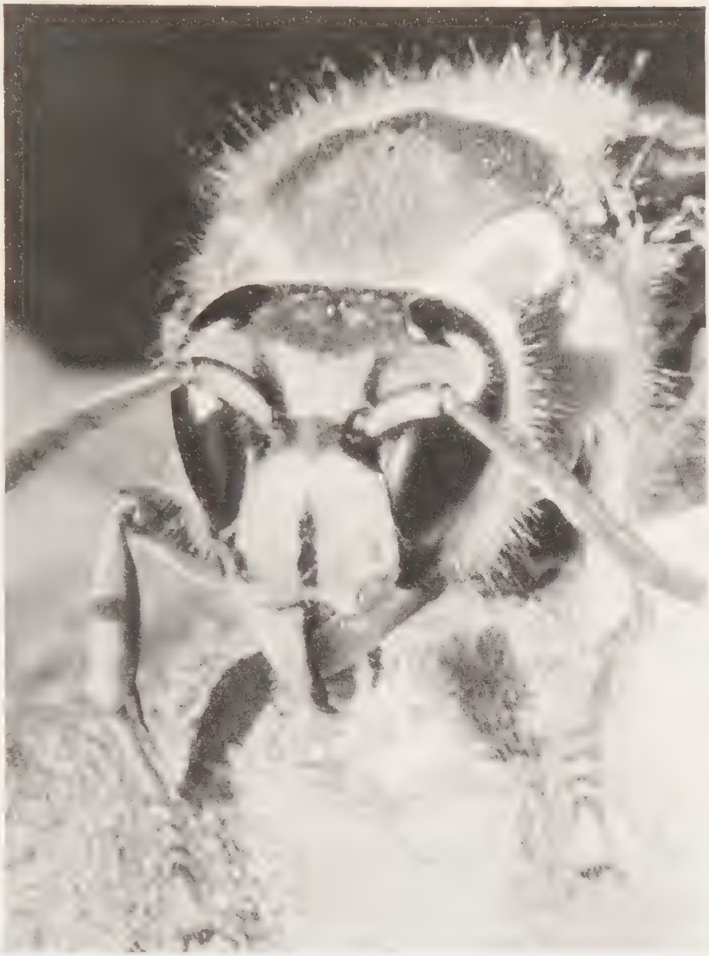
Some species, with their antennæ removed or covered with shellac, are unable to find either food or each other. If their eyes are blindfolded with pitch and their antennæ left in normal condition, they seem to suffer no inconvenience.

Fabre's classic experiments with the great peacock and banded-monk moths* and with the truffle beetle show to what inconceivable lengths the sense of smell sometimes is developed.

The great peacock moth, the largest in Europe, is clad in chestnut velvet, with a necktie of white fur. Its wings, sprinkled with gray and brown, are crossed by a faint zigzag, edged with smoky white, and studded by a great eye with a black pupil and a variegated iris containing successive arcs of black, white, chestnut, and purple.

A female moth of this species emerged from her cocoon in Fabre's laboratory one May day. That night there came such a swarm of male moths that everybody was astounded. In the laboratory, in the kitchen, in the dining room they gathered. At least forty lovers had come to pay their respects to the marriageable bride born that morning. In

* See "Strange Habits of Familiar Moths and Butterflies," with sixteen pages of illustrations in full color, by William Joseph Showalter, in the NATIONAL GEOGRAPHIC MAGAZINE for July, 1927.



Photograph by Lynwood M. Chace

LOOKING A HORNET IN THE EYE

With its large kidney-shaped eyes, its jointed antennæ, and its pincerlike mandibles, a hornet presents a fearsome aspect when magnified. The members of this family feed their young chewed-up bits of other insects (see text, page 52).

eight days at least 150 wooers came to pay court to the moth virgin. Whence came they? Extraordinarily rare in Fabre's region, he thought that some of them must have traveled at least a mile and a half.

Surrounded with naphthalene, the young virgin's call still went forth and the lovers still came hence; but shut up in an air-tight jar, not a single visitor arrived to pay court. When the antennæ of a visitor were cut off, an operation through which he evinced no pain, he became powerless to locate his affinity, though she was only a few feet away.

So it was with the banded-monk, a day flyer. A chance cocoon fell into the entomologist's hands. The oaks, where the banded-monks made their home, were miles away. Three years of diligent searching upon his own part and that of his family had failed to reveal a single member of this species in any of its stages from egg to adult.

But as soon as the newly hatched insect had reached the mating age swarms of banded-monk wooers came from somewhere out of the distance to pay court to her. This time the naturalist exhausted the whole list of powerful scents and stenches in an effort to overpower her "call." With what he called the concentrated odors of a gas works, a smoker's divan, a scent shop, an oil well, and a chemical factory, he still was unable to conquer the emanation that called the swains from over the hills.

We admire the amazing delicacy of the bird dog's nose. Going at a gallop, on his zigzag way across a field, he recognizes the scent of the quail from that of any of the thousand and one other odors issuing from grass and flower and shrub, from insect and bird and beast. Not only so; he discriminates between several kinds of quail scents, whether they be of the body, foot, or nest; whether fresh or old, or from birds approaching, standing still, or fleeing.

But even the setter's nose is a dull organ of perception beside the antennæ of moths, beetles, bees, and butterflies.

Photograph by Paul Griswold Howes

ANT GALLERIES IN THE CENTER OF A DEAD CEDAR TREE

At the base of the tree which furnished this picture were found fully two bushels of sawdust and chips which have been removed, bit by bit, by industrious carpenter ants (see, also, illustration, page 16). The termites join the carpenter ants in mining wood. Between them the beams of thousands of houses and other structures are weakened and in many communities the problem of termite-proofing structures becomes a serious one.

We are so accustomed to seeing animals with their organs of hearing located in their heads that we are astonished to find that insects have other locations for their ears, and that they employ several principles beside the tympanum in translating air vibrations into sound.

PECULIAR POSITIONS FOR EARS

Among the short-horned grasshoppers (see Color Plate II) the ears are in their abdomens, immediately back of and above the point where the hind legs emerge from their bodies. These appear as small, clear, round spots on the surface of the abdomen.

Katydids and crickets hear with their front legs, in which are located the ears that catch the music of their sweethearts' songs. Among the mosquitoes and midges the ears are in the antennæ—very delicate hairs that communicate the sense of vibration to certain nerves, which, in their turn, transmit it to the brain.

The throat is no more the source of the insects' song than is the head the seat of their ears. Some employ the principle of the violin; others a variation of the drum; still others the idea of the reed. Some make secondary music with organs built after the fashion of the flute, while many employ sign language as effective means of communication.

DRUMMERS AND FIDDLERS

When one hears the sonorous accusation that Katydid (see Color Plate III, figure 3), it can be written down that another Adam is laying the charge at the door of another Eve, for the females of the Katydid family are voiceless. Mr. Katydid has his say with his wings. He rubs his nervure-roughened front wings together. On the one there is a filelike roughness, and on the other a resonant edge—an application of the fiddle-and-bow method of sound production. The

Photograph by Paul Griswold Howes

A PAIR OF ANTS MAKE THEIR TOILET

Living in dark burrows where the sun never enters, cleanliness is a rule of the ant community. They patiently scrub their bodies with their mandibles, so as to remove all adhering particles of dust. The positions into which they have to get to complete their tasks are often startling. Often one may be seen balancing itself on two legs and swinging its abdomen up to its mouth to brush and stroke it with meticulous care. The photograph is very much enlarged.

crickets also are Fritz Kreislers instead of Carusos.

The hum of many orders of insects is a sound produced by the reed method—the rapid vibration of a tongue of some material. In the case of the bee and the fly, one wing is the tongue. The droning among the flowers, the quivering notes when enmeshed in a spider's web, the high-pitched buzz when making a getaway from such a trap—all these speak so plainly, even to human ears, of amiability, anxiety, or anger that one cannot avoid the conclusion that the bee knows how to express her moods as well as we.

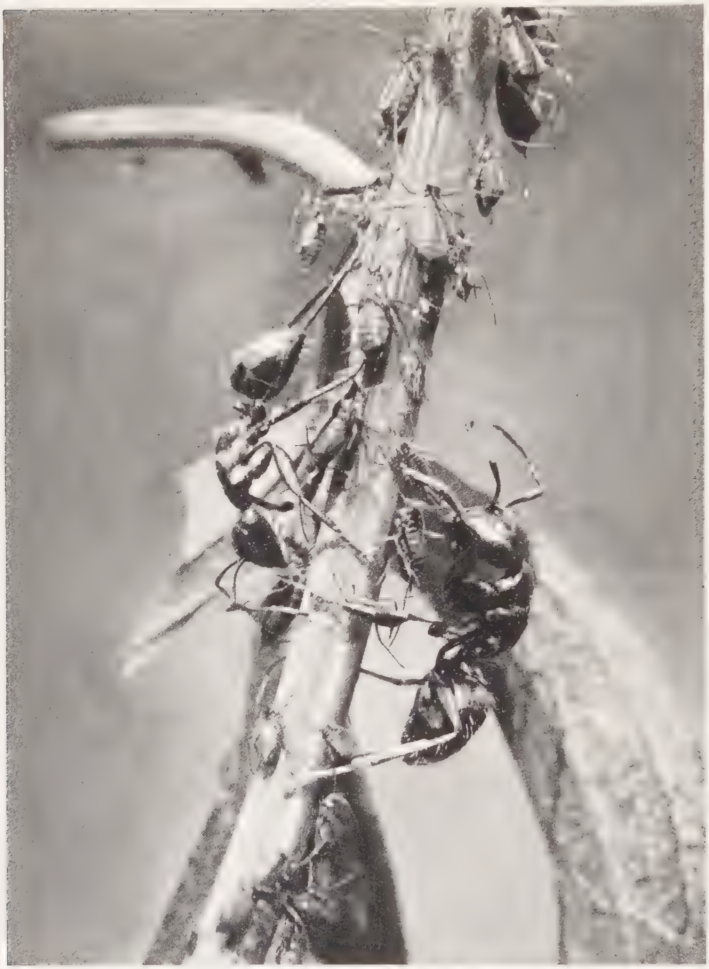
There is still another kind of sound production. When a fly gets fast in fly paper we hear its shrill, high-pitched, nervous cry, although its wings are pinioned by the glue. That sound comes from tiny tracheæ, or tubes, with which the body is shot through. The bees have a voice produced in the same way, and any beekeeper will describe the piping of his bees.

It is by piping that the lady mosquito, intent on a meal of warm blood, gives the intended victim warning, thus proving that she is a bold highwaywoman rather than a cowardly thief.

FEATS OF STRENGTH AND ACHIEVEMENTS IN ENGINEERING

When man's strength and achievements in engineering are measured by the standards set by the insects, there are some phases of our success that are overshadowed entirely. In the last Olympics the record for a standing high jump was 6 feet 4⅜ inches. Yet the common flea—*Pulex irritans,* if you want his more exact name—is capable of jumping a hundred times as high as his own head. Were the Olympic champion high jumper able to do as well proportionately, he could clear the Washington Monument at a single bound, with some eighty feet to spare.

Likewise, if man's biggest structure were as large in proportion to the size of



Photograph by Paul Griswold Howes

CARPENTER ANTS AND THEIR APHID CATTLE

Many ants are stock raisers. They herd their colonies of aphids with as much care as a western plainsman tends his cattle. In utilizing the corn-root aphid a remarkable degree of intelligence is shown. In the fall the little insects are taken, in one or another of their stages of life, into the nests of the ants and carefully protected during the season of cold. In the early spring they are carried to the roots of the smartweed and other related plants, where they are "pastured" until the farmers' corn takes root. Then they are carried to the corn roots, which serve as grazing ground for the summer. Each aphid has a tiny tube on the upper rear part of its body, through which it secretes droplets of a sweetish substance which the ants drink with gusto.

the adult human frame as the Pennsylvania ant hill is to the size of the ants that built it, we could boast of a pile five hundred times as big as that wonder of the ages, the pyramid of Cheops; and the Eiffel Tower, built with the aid of all sorts of machinery, is no higher, proportionately, than the ant hill reared with claws and mandibles alone. If the modern baggageman could carry loads as heavy, in proportion to size, as the ants, he could lift a half-ton trunk to the top of the Washington Monument without apparent fatigue.

Kirby and Spence have pictured the strength of insects: "A wild bee or a Sphex (see Color Plate X, figure 1), for instance, will dig a hole in a hard bank of earth some inches deep and five or six times its own size, and labor unremittingly at this arduous undertaking for several days, scarcely allowing itself a moment for eating or repose. It will then occupy as much time in searching for a store of food, and no sooner is this task finished than it will set about repeating the process, and before it dies will have completed five or six similar cells or even more.

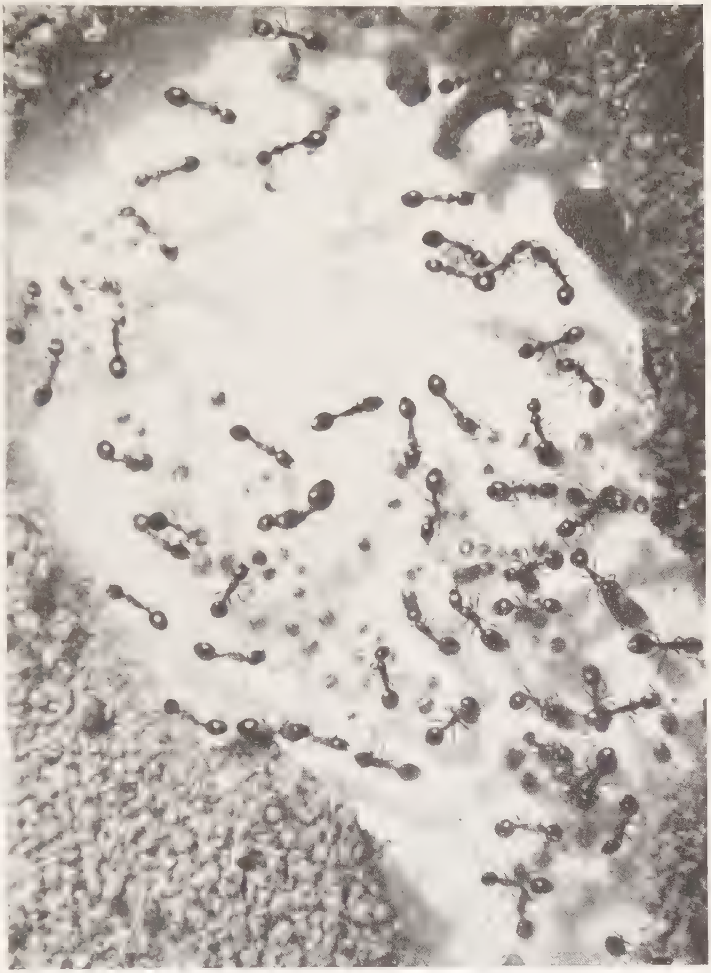
"If you would estimate this industry at its proper value, you should reflect what kind of exertion it would require in a man to dig in a few days, out of hard clay or sand, with no other tools than his nails and teeth, five or six caverns twenty feet deep and four or five square, for such an undertaking would not be comparatively greater than that of the insects in question."

THE COLORS OF INSECTS

Matching the fairest flowers that blow in the richness and iridescence of their coloring, some of the beetles, bugs, and bees rival the butterflies and moths, and even seem to challenge the rainbow itself, in their harmonies of hues (see Color Plates I to XXIV).

The dung beetles of the South American pampa, we are told, combine the fire of gems with metallic luster, and, according to the incidence of light, emit the green reflections of the emerald or the gleam of ruddy copper—rakers of muck that would do honor to the jeweler's showcase.

What Golconda do the scarab (see Color Plates XXIII and XXIV), the azure hoplia cockchafer, the golden apple beetle, and other species visit to gather their gems, and in what diggings do they find their golden nuggets?



Photograph by Paul Griswold Howes

THE BUSY ROUTINE OF AN ANT HILL

The queen is the largest individual, in the center of the picture. In the group of five ants in the upper right corner two may be seen combing each other, a third is carrying an egg, while the other two rest. At the top is a worker carrying a ball of earth. Whether herding aphid "cows" (see opposite page), making slave raids, growing "mushrooms," or looking after guests of the colony, the ants disclose a remarkable social organization.

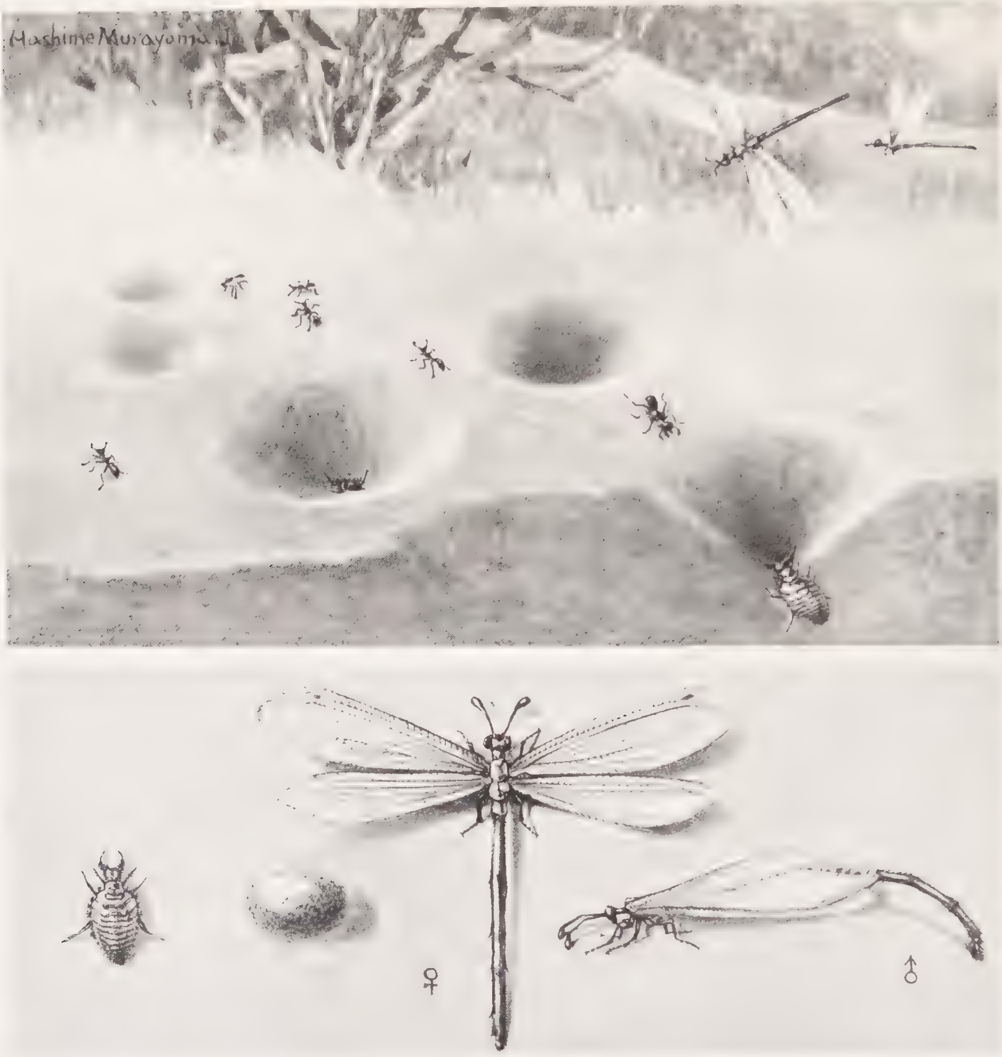
THE REASON FOR INSECT COLORS

The general harmonizing of insect color and pattern with the color scheme of usual environment is recognized generally. It is the art of camouflage developed by ages of necessity for low visibility. Those insects hardest to see have the best chance to escape the birds, the lizards, the toads, and the predaceous insects of other species. Even in a single species, varieties of coloring are found in different localities. In each case the harmony between the insect and its environment is maintained.

Some insects mimic the colors of other species as a protection. The mimicking species are edible to their natural enemies, while the mimicked ones are noted for their repellent taste and therefore are given a wide berth by insectivorous creatures. The nearer the edible folk can imitate the nonedible, the better chance they have to escape a hungry mouth.

THE SEVERAL STAGES OF EXISTENCE

On the other hand, there are some insects noted for their high visibility rather than for their success at camouflaging. They are nearly all distasteful to the insec-



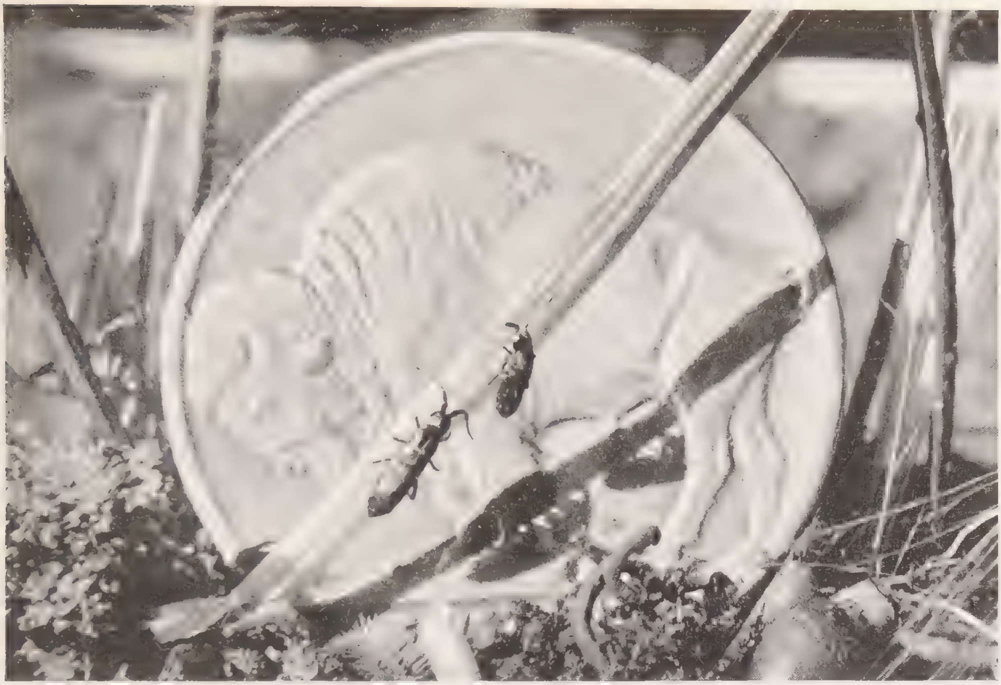
Painting by Hashime Murayama

TRAPS MADE BY WINGED LIONS TO CATCH ANTS

Often one sees symmetrical little craters in dry, sandy spots. These are pitfalls for ants. The winged lion shown below (female left, male right) lays her eggs in sand, and out of these emerge larvæ in the form shown at the lower left of the picture and at the bottom of the cut-away crater. The ant that slips over the edge of one of these traps finds the sand exactly at the angle of repose and can get no foothold to crawl out again. The larva, sensing his struggles, comes out of the sand and captures him. One may induce the little creature to come out simply by tickling the sand in the crater with a straw.

tivorous folk, and they advertise themselves in bold-face type, so that the foe may "read as he runs" that they do not belong to the edible species. Some moths and flies (see Color Plate IX) that are perfectly harmless duplicate in coloration, as well as in outline, bees and wasps that have frightful stings.

The transformations that take place in the insect world are marvelous adaptations to environment. From the tiny egg to the repulsive caterpillar, and thence to the beautiful butterfly; from the slim egg to the fat grub, and thence to the iridescent June beetle; from submarine-building caddis-worm to the lace-winged fly; from



Photograph by Paul Griswold Howes

A GROUP OF SPRING-TAILS BEFORE A BUFFALO NICKEL

These are among the most primitive of the insects. They possess a triggerlike apparatus on the under side of their bodies. When the trigger is released the insect is able to spring great distances. The spring-tails occur all over the world—on land, water, and ice.

the microscopic bee-louse to the blister-beetle—these are a few of the changes that take place in many species.

THE SEVERAL STAGES OF EXISTENCE

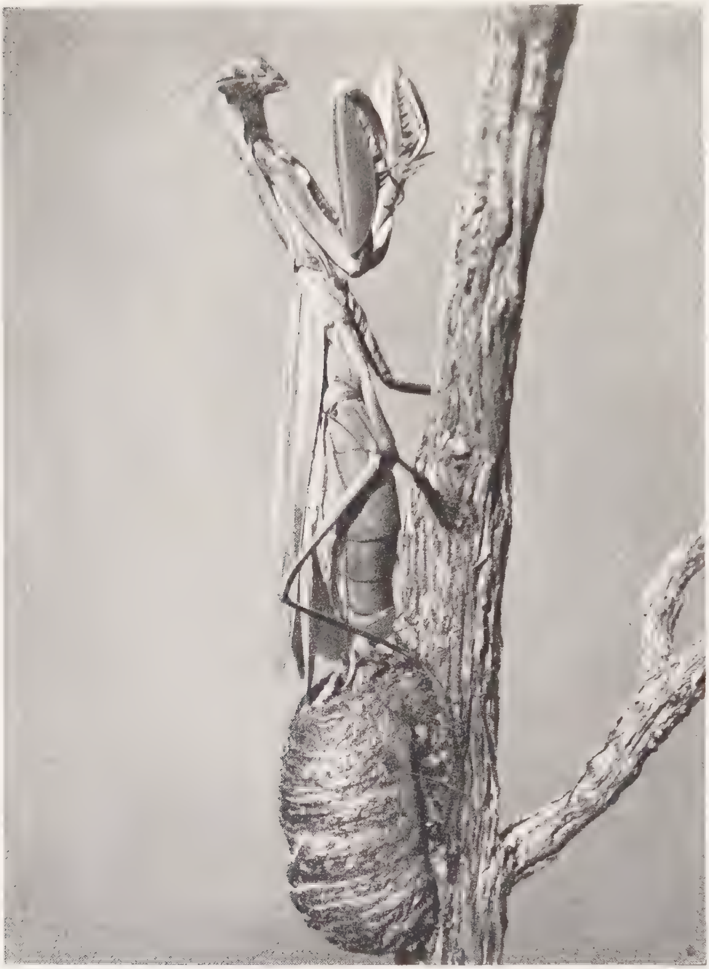
Some species undergo no striking changes on their journey from the egg to the grave except to grow wings. Other species, more numerous, such as the locusts, katydids, crickets, and dragon-flies, undergo striking changes of environment and partial changes in their make-up. In their larvæhood they live in the ground or the water. As adults they could not survive such surroundings. They have many molts. As they outgrow one suit of clothes, it splits open on the back, and they creep out, all "dolled up in a new bib and tucker" of more liberal dimensions. This hardens because of the chitin in it, and splendidly serves its purpose until again the body is too big for its garb, when another splitting on the back marks the acquisition of a more commodious garment.

Various species have their own definite number of molts. The Seventeen-year Locust is thought to get twenty-five new costumes during its heyday of life.

But the beetles, the butterflies, the moths, the bees, the ants, the wasps, the fleas, and such undergo utter transformations—from the egg to the maggot, from the maggot to the pupa, and from the pupa to the fly; from the egg to the caterpillar, from the caterpillar to the pupa, and from the pupa to the moth. The muscles change, the digestive tract is transformed, the creature's whole being is so made over that the environment of its one form would be fatal to its other.

Imagine a butterfly eating solid food, a June beetle (see Color Plate XXIII, figure 9) forced to live under ground, or a caddis-fly trying to dwell at the river bottom!

But the caterpillar does not eat for today alone. It foresees a morrow when, undergoing its transformation, it will have to spend days on end without a single bite



Photograph by Paul Henri Fabre

A PRAYING MANTIS (ACTUAL SIZE) LAYS HER EGGS

The mantids deposit their eggs in curious masses, covered with a quick-drying mucus, on branches and plant stems, in the late summer and fall. From these the young emerge during the following summer and soon grow to maturity, molting several times and developing wings in the interim (see text, page 28).

of food, the while its entire interior, except possibly its nervous system and reproductive glands, turns into a thick fluid in which float bits of degenerating tissue. While the débris of the disintegrating larval body is being melted into liquid in this strange alembic of Nature, the fluid, in its turn, is being transformed into new tissues and new organs.

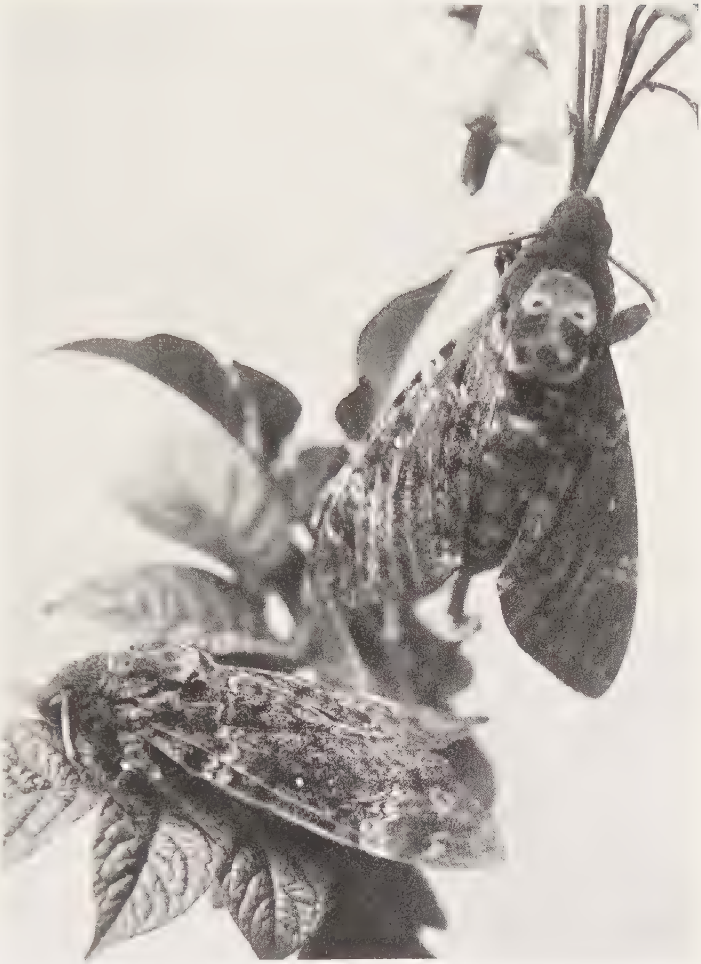
MARVELOUS MANIFESTATIONS OF INSTINCT

"One marvels," observes an English naturalist, "at the skill displayed by the bird in constructing its first nest; but it may be said that the newly mature bird has at least had a chance of watching a second-year matron of its kind building and getting some hints that way. In the case of the insects there is, as a rule, no possibility of such help. In the majority of species the mother is dead long before the daughter comes to that stage of existence when the necessity of providing for her progeny arises; so the knowledge has to pass by way of transmitted memory.

"Somewhere in the minute speck of protoplasm constituting the egg of one of the solitary bees, for instance, there is an infinitesimal particle of nerve matter which contains the secret of how to cut accurate circles and ovals of roseleaf so that a given number of them will overlap and curve into a perfect cylinder. During the greater part of its life the creature which hatches from that egg will have no need of the secret, but the germ of it will go on developing, and when the bee has reached its adult form there is the idea in the memory cells ready to instruct the nerves that govern the action of wings and legs and cutting jaws."

The milkweed butterfly sips the nectar of flowers and never touches green leaves. Its caterpillar, however, would starve on rations of nectar. The butterfly knows, or—to be literally accurate, instead of figuratively correct—acts as if it knows, that the caterpillars which are destined to hatch from the eggs it lays must have green food, so it always lays them on leaves.

Likewise, one of the Meloe blister-beetles, cousin of the Spanish fly, lays its eggs by the thousand—perhaps four thousand the first day, three thousand the second, two thousand the third—near the burrows of certain mining-bees. Then, exhausted by the Herculean task of insuring the perpetuation of the species, the mother beetle crawls away and dies. Presently an innumerable host of small creatures come out of the ground, seek out the flowers frequented by the bees, such as the composites, and then hop onto the bees' backs as they come for nectar and pollen.



Photograph by Paul Henri Fabre

THE DEATH'S-HEAD SPHINX MOTH

Somehow this strangely marked insect has learned the secret of the queen bee's piping and has mastered the art of imitating the call of the mistress of the hive. The bees could without difficulty sting it to death. But they allow it to enter without protest and to lay its eggs. The larvæ spin webs that do great damage to the bees' household.

A MURDERER UNMASKED

For a long time these tiny creatures were believed to be a species of louse infesting the bees, until Newport, the English entomologist, found them to be the babies of a Meloe beetle. Then Fabre studied them and found further that after one is safely ensconced in Mrs. Bee's fur it rides around on its animated airplane until she has provisioned her cell with pollen and honey. Then, at the moment the bee lays her egg on the pollen and honey, the little scamp makes a flying leap from the back of its hostess and lands on the newly laid egg, which it proceeds to use both as a life raft and a larder.

The poor bee, aiming to plant a germ of life, unwittingly permits this germ of death to fasten its tentacles to her hopes. She seals up the cell, but not for her own. The baby Meloe promptly tears open the shell and proceeds to feast upon the contents of the egg. Then it goes to sleep. For several years it stays in the cell it stole from the bee, taking divers naps therein, each time waking up transformed, and finally emerges a full-fledged Meloe beetle, ready to start the cycle all over again.

Only once in its life did the tiny creature have occasion to seek out a plant in which to hide; only once, occasion to steal

Photograph by Paul Griswold Howes

MASSES OF FROTH MADE BY FROG-HOPPERS

The frog-hoppers are a group of small, flat, brown or gray insects, which occasionally occur in sufficient numbers to injure grapes, cranberries, or pasture grasses. They get their popular name from the belief that these masses are the spittle of tree frogs. Their young, which in the earliest stages have no wings, a little later developing wing pads and finally wings, often are found imbedded in these masses, which apparently are used for a shelter.

a ride; only once, occasion to select a laying place contiguous to the harvest bee's home. Yet, with all the order of the succession of notes in a run on the piano, each act was performed with a sureness and a deftness as only man can show in his doings after years of training.

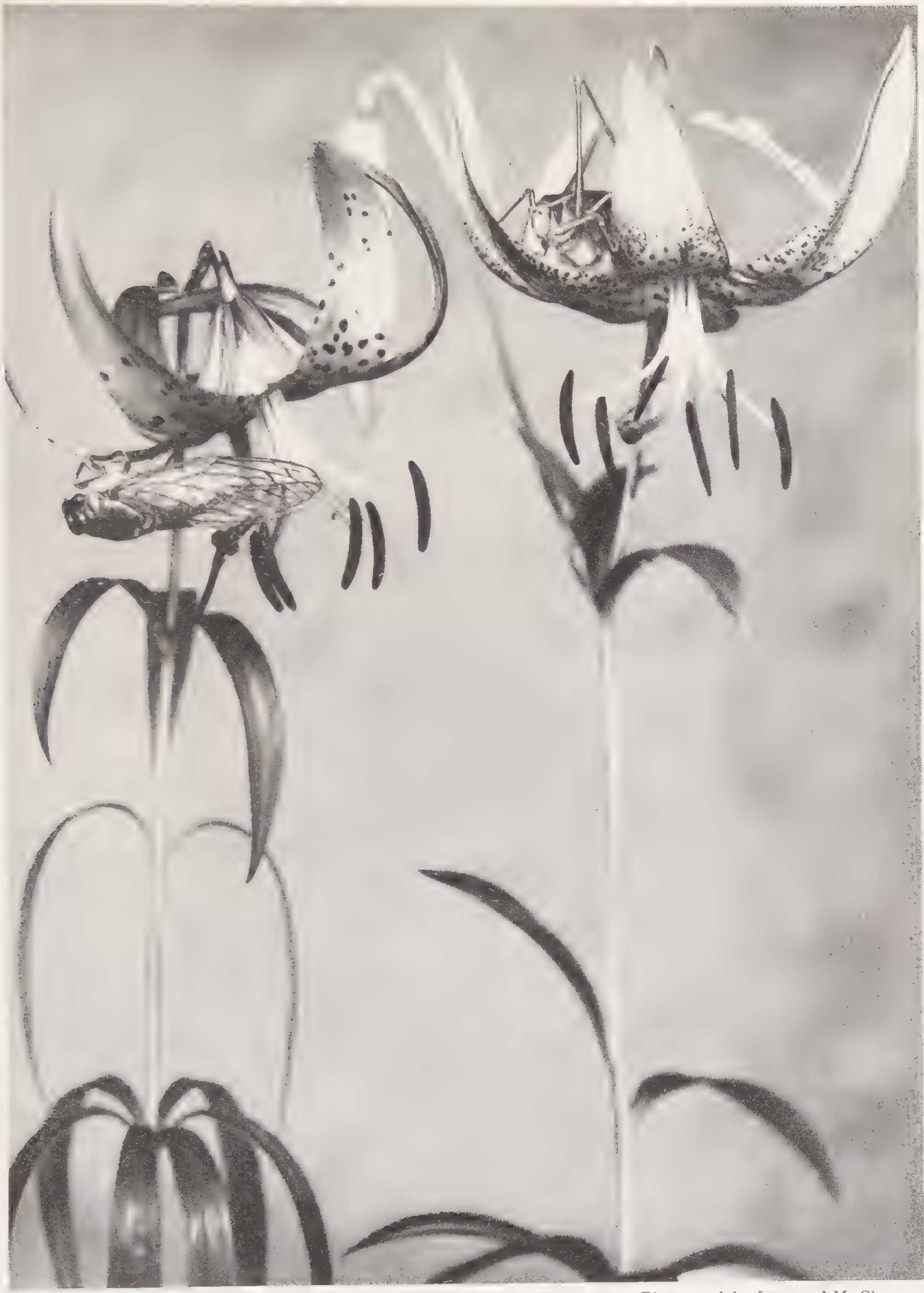
THREE YEARS IN THE SILENT HEART OF THE OAK

So, too, it is with the oak-boring grub and the long-horned Capricorn beetle (see Color Plates XX and XXI) into which it is transformed. From an egg in a crevice in the bark of a tree does this grub come into existence. The mother is dead long before the grub begins to live. A tiny creature it is when emerging from the egg, but with a powerful set of woodworking tools in its head.

Three years it will spend eating its way through the wood of the tree. In the silent, somber solitude of the oak's inmost heart it eats its ever-broadening, ever-lengthening path. It has no eyes, for of what use could eyes be to a creature living in the utter absence of light? It lacks ears, for what could there be of interest for it to hear when utter stillness reigns perennially? And nose—what warning could a nose give, what gustatory delight, what olfactory happiness, where there is nothing but oak wood to meet, nothing but oak wood to eat, nothing but oak wood to smell?

And yet "this-nothing-at-all is capable of marvelous acts of foresight; this belly, which hardly knows aught of the present, sees very clearly into the future." After three years of eating, it finds itself called into the deep sleep from which it is destined to awaken as a full-fledged, stiff-armored, long-horned Capricorn beetle.

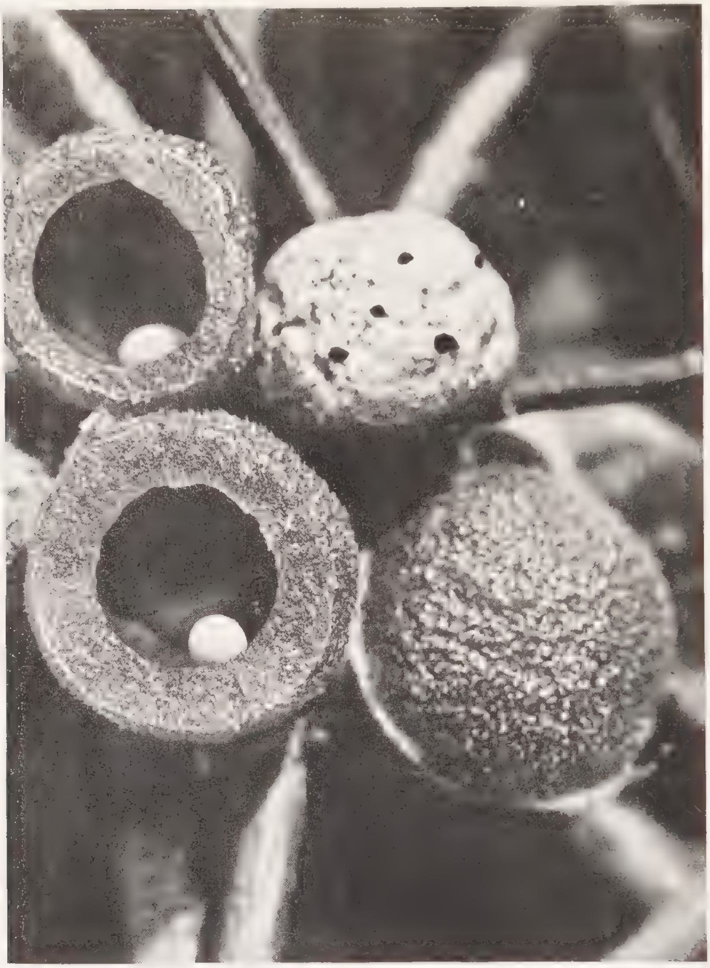
Urged on by an unfathomable presentiment to prepare for what never has happened before in its experience, at this juncture the grub bores to the surface, even braving the keen ears of that ancient



Photograph by Lynwood M. Chace

A SONGSTER OF THE DAY AND A SERENADER OF THE NIGHT

Hanging on the Turkscap lily at the left is a harvest-fly whose tuneless buzz fills the air on an August day. Upon his colorful balcony at the right Mr. Katydid looks out upon the scene. But his undefined accusations against the mysterious Katy (see text, page 14) will not be heard until eventide, when the harvest-fly is wrapped in silence.



Photograph by Paul Griswold Howes

A GROUP OF GALLS MADE BY INSECTS

One often notes galls on plants of many kinds. While some of these peculiar formations are caused by certain kinds of fungi, most of them are produced by insects. The two open and one closed gall are of a type developed by one of the cynipid gall-flies. The whitish gall was produced by another species, whose young have emerged. In the two opened galls lie small capsules, out of which would have emerged young gall-flies if they had been undisturbed. The gall-making insect lays its egg in the twig, where an irritation results in a swelling which serves as a shelter for the young.

foe of its race, the woodpecker, in order to provide an exit way for the beetle to be. Then it retreats a bit, excavates a transformation chamber, which is lined with a swan's down fabricated from sawdust. This is barricaded with triple doors made from uric-acid secretions and bits of wood fiber. After these elaborate preparations, the grub lies down to the deep sleep of the transforming period.

But does this sleep-overtaken grub ever turn its head away from the exit? Not it, for by some strange plan of Nature this animated sausage has inherited the guidance that makes it act as if it had full foreknowledge that it is destined to wake up a full-fledged beetle, too stiffly armored and too well provided with horns to permit it to turn around in its narrow cell.

STRANGE COMBINATIONS OF WISDOM AND IGNORANCE

Perhaps the French larva known as the Pine Processionary, a tent-building caterpillar resembling in some ways our own familiar apple tree tent-caterpillar, affords entomology's classic example of blind ignorance coupled with seemingly surpassing intelligence.

Fabre, in his "Souvenirs entomologiques," gives a dramatic picture of this caterpillar's behavior under varying circumstances. It is the larva of a moth closely related to the silk-worm moth. In laying her eggs, this moth takes down from her own body to make a cover for her eggs, just as the eider duck plucks the downy feathers from her own breast to make a warm nest for her young.

After emerging from the clustered eggs in late summer, the tiny caterpillars set to work to build themselves temporary silken tents; but when the tang of autumn touches the air, they construct a larger habitation, of such strong silk that it can weather the winter gales without difficulty. By the end of winter this may be as large as a half-gallon measure — "the interior a combination of a ragshop and a sewage farm."

As they march forth from their tent on a sunny day for a meal of pine needles, the caterpillars travel in single file. There are no natural leaders, whichever happens to go first being, for the moment, the leader. Now it is this one and now that, but each caterpillar leaves a trail of silk behind it that acts as a life line to guide it back from the grazing grounds to the nest.

One day Fabre succeeded in getting a procession to start around the rim of a big palm vase. He cut the line where it reached the rim, and the caterpillars, completing the circuit of the rim of the vase, unwittingly, guided by the life line they had left behind, started around again. All day long they kept marching around and around, for there was a solid ring of caterpillars, each with its head to the tail of the one before it. Far into the night they still journeyed on, slaves to their life line and bound to follow the one ahead. Morning dawned, finding them motionless and in a torpor, but still in formation.

With the warmth of the sun upon them and the urge of their appetites within them, they resumed their patient march. On and on, around and around they went. Night came again, with its weary halt, and another morning with its patient resumption of the unending path. A few stragglers sought a way out of the circle, but came back and resumed the gruelling march. The third night came, with its halt, and another morning with its marching. So the fourth and the fifth. Footsore and weary, there were stragglers and confusion. The ring of caterpillars became a series of short processions, which again were united before the close of the

Photograph by Paul Henri Fabre

A GLOWWORM EPICURE DINES ON SNAIL

Stealing up on the snail, the assailant administers an anesthetic so subtle that the victim is not aware that it has been attacked. After the anesthetic has become effective the glowworm covers small sectors of the victim's body with a peptonized saliva, which predigests the snail's tissue and turns it into an edible broth.

Photograph by Charles Martin

A FLIGHT OF LOCUSTS OVER AN ISLAND OF THE SULU SEA, PHILIPPINE ISLANDS

day. The sixth night, the seventh day, the seventh night, and still the go-round that was far from merry kept up, and with its marchers as footsore and weary as were ever members of Stonewall Jackson's foot cavalry or John J. Pershing's heroes of the Argonne drive. The eighth day dawned, and with it came a desperation that led them singly and in groups to fall out of ranks, and before night had come again the last one had found his nest once more.

FORECASTERS OF THE MORROW'S WEATHER

Eighty-four hours on the march and eighty-four in bivouac, with never a mouthful to eat, with never the comforts of the home nest, all because of a slavish devotion to a life line and the instinct to follow the fellow ahead!

Prize "boneheads" of insectdom? Perhaps so. But wait! These same caterpillars, to whom being caught out in a rainstorm would be fatal, have developed, Fabre tells, methods of forecasting the weather that for weeks, during careful observations and comparisons with the records of the French Bureau of Meteorology, showed an amazing foreknowledge of the approach of foul weather.

Fabre, who has been called the "Homer of the Insect World" and the "Incomparable Observer," and whose son is following in his footsteps through his striking photographic researches, as revealed in many of the illustrations accompanying this article, has written at length on the strange intermingling of blank ignorance and surpassing foresight among the winged hosts.

SKILLED INSECT SURGEON HAS A MENTAL "BLIND SPOT"

The Pelopæus wasp, a splendid potter and an exquisite surgeon, able, with equal facility, to build an ideal cell for her unhatched young and to paralyze, without killing, the spiders with which she provisions it, was unable to detect the removal of the first spider, with its attached egg, when she brought in the second one. Furthermore, she was unable to detect even the removal of the cell itself, and proceeded to plaster the bare spot where it had been, even as if it were there.

Likewise, the familiar Sphex wasp, one of the most highly skilled huntresses of the insect world, knows exactly what species to capture for her future babies, where to sting them so as to produce paralysis instead of death—meat preservation without salt or cold storage—but she seems to display utter stupidity at times. It is her practice to leave her cricket at the entrance while she goes below to see that all is well before she takes it down. Forty times Fabre moved the cricket back from the entrance no more than six inches. Forty times Mrs. Sphex dragged it up to the entrance again, going down each time for another needless inspection.

Some species of Bembex (see Color Plate X) wasps do not provision their burrows, but bring the prey to their young as they need food, after the fashion of the birds. The entrance to their burrows is always in the sand. After getting down a little distance in more substantial soil, the gallery runs approximately parallel to the surface. On the surface there is no mark by which even a Fabre can detect the entrance.

Whether Mother Bembex comes in or goes out, the door of sand always closes behind her. She wanders far in search of prey, but always finds her doorpost as easily and definitely as if it were so plain that those who run might see it. Yet if one excavates the gallery, leaving the entrance intact, she will go through the door, come out of the open gallery, go through the door again, and repeat the performance again and again. At the end of the gallery lies the grub that was the object of her maternal solicitude, the baby for whom she worked day in and day out. She does not recognize it now. She tramples upon it, ignores its presence as if it were only so much clay. It is not recognized for itself; she knows it only when it lies at the end of the gallery to which her doorway leads.

Even when the doorway is obliterated, with the gallery left intact, she recognizes neither the gallery nor the grub at its terminus. Her baby may starve before she will feed it, if either door or hallway is disturbed. She recognizes her offspring only as the grub that lies at the end of an undisturbed gallery leading from a door through which she passes.

COUNTLESS WONDER STORIES

One might wander indefinitely in the realms of insectdom, discovering at every step things that make the most blasé among us pause and ponder.

Parasitism, in which members of one species lay their eggs upon the bodies of other species, or even inject their living young into the bodies of other species; parthenogenesis, in which as many as 94 generations have been produced without the interposition or birth of a single male (page 3); ability to hibernate, in which some individuals have been known to sleep more than forty years and wake up—ten thousand wonder stories might be told of these strange creatures in whose lives is more romance than all the fiction writers in Christendom have been able to conjure up.

For a discussion of specific species and families of insects and their habitats, see pages 28 to 87.

INSECT RIVALS OF THE RAINBOW

IN THE accompanying text pages will be found, in more detail than was possible in the general story, some of the outstanding events in the lives of the insect families represented in the 24 accompanying Color Plates.

A large number of the species portrayed in color come from the Tropics. But family relationships endure beyond geographic boundaries and are more persistent than either color or cut of clothes. So, every brilliant tropical insect has its drab cousins and common family bonds in temperate lands.

The biographies deal broadly with the families and give details that apply to those members most familiar to man in everyday life.

CRICKETS, COCKROACHES, KATYDIDS, AND THEIR KIN

(Order *Orthoptera*)

Plates II and III

This order embraces six families, represented respectively by the short-horned grasshoppers, the crickets, the katydids, the walking sticks, the mantids, and the cockroaches. The individuals of the first three families sing and jump, while those of the latter three are mute and creep. Almost all of the music of the insect world comes from the three singing families of the *Orthoptera*. Indeed, the cicada is the one famous maestro that does not belong to this order.

Short-horned Grasshopper Family (*Acrididae*). The short-horned grasshopper family, distributed all over the world, has about 500 species in the United States. To it belong the Rocky Mountain locust, which in days gone by caused Kansas to be known as the "hopper" State, the Argentine locust, which frequently descends upon the pampa from the foothills of the Andes and eats everything bare before it, the locust that was among the Plagues of Pharaoh, and that other one which figured in the diet of "locusts and wild honey" mentioned in the Bible.

The life histories of most of the short-horned grasshopper and locust species show little variation. The females deposit their eggs in small oval, or bean-shaped packets, either in the soil, at the base of the stems of grasses, or in soft wood. The fall-deposited eggs do not hatch until spring.

The species reproduced are: Autumn Yellow Winged Grasshopper (*Arphia xanthoptera* Burm. Plate II, figure 1), occurring in the northeastern United States in autumn; African Grasshopper (*Atractomorpha aberrans* Karsch. Plate II, figure 2), coming from central Africa; Eastern Lubber Grasshopper (*Romalea microptera* Palis. Plate II, figure 6), occurring in the hay fields of southeastern United States; Yellow Winged Grasshopper (*Arphia simplex* Scudd. Plate III, figure 2), habitat the Mississippi Valley; European Grasshopper (*Monachidium lunus* Joh. Plate III, figure 4), occurring alike in Europe, Asia, and Africa; Desert Grasshopper (*Leprus cyaneus* Cockerell. Plate III, figure 6), habitat the arid areas of southwestern United States; Old World Migratory Locust (*Locusta migratoria* Linn. Plate III, figure 7), occurring in Europe.

Walking Stick Family (*Phasmidae*). This bizarre group, some of whose members disguise themselves by simulating twigs and leaves, contains about 600 species, mainly tropical. Sixteen species are native American, the most familiar being the walking stick or devil's darning-needle. The eggs, one-eighth of an inch long, of polished black, with a whitish stripe on one side, are scattered on the ground in the fall, where they lie until the warm days of spring. The female, unlike most Orthopters, makes no provision for their safety. If certain species of walking sticks lose a leg another grows in its place.

The species reproduced is: Walking Leaf (*Pulchriphyllium bioculatum* Gray. Plate II, figure 3), habitat African coast.

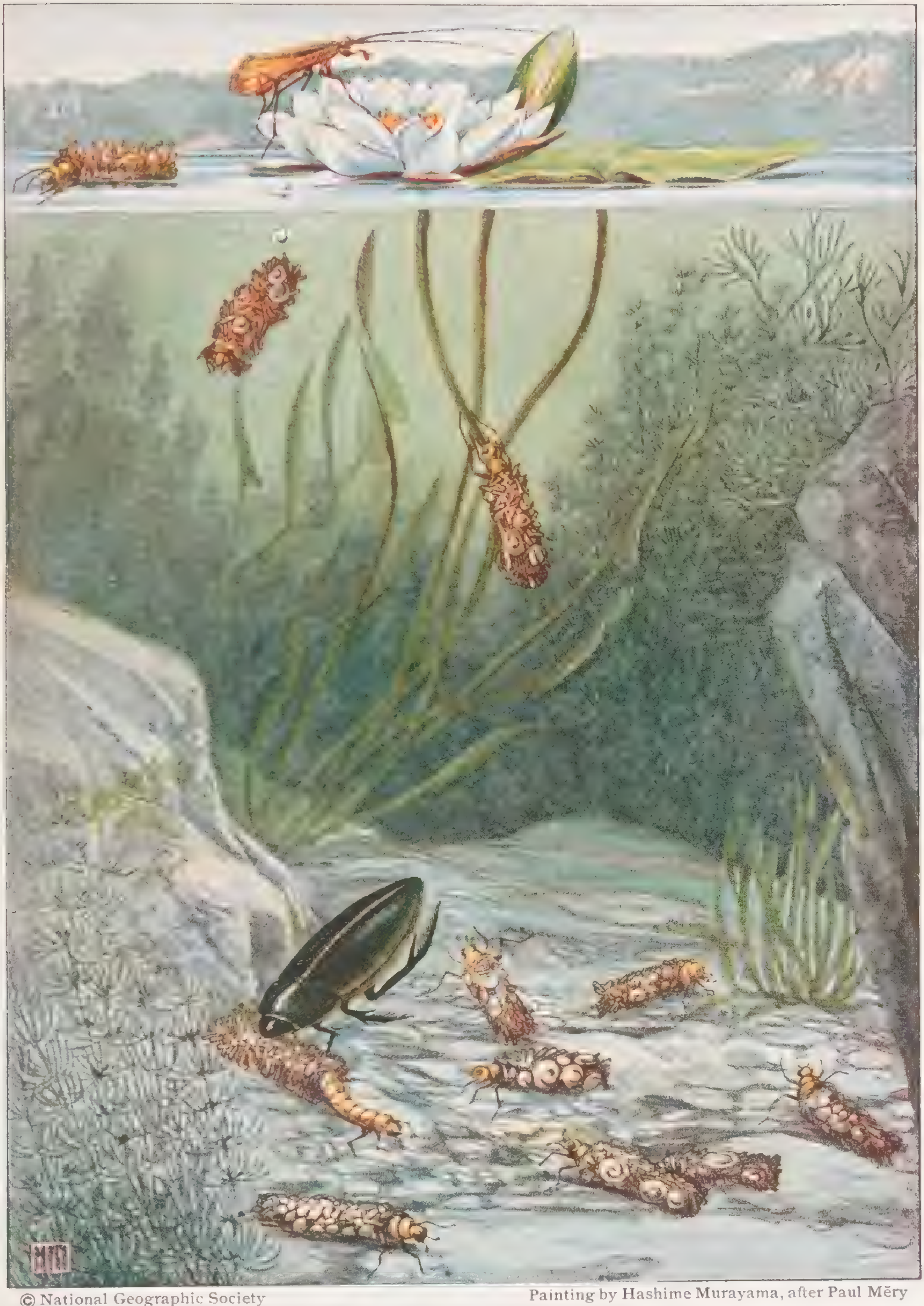
Mantis Family (*Mantidae*). The mantids are a carnivorous tropical tribe, with many species having wings resembling the leaves of plants, both in coloring and formation. Perhaps a score of species are found in the South, one of them extending its habitat as far north as Maryland and Indiana. The egg cases approximate the size and shape of an almond, and the color of golden grain, the substance of which they are made being akin to silk—a frothy mass whipped until it turns to a foam and hardens.

It has been remarked that although the attitude the mantis assumes may seem to be that of devotion, such sanctimonious airs are a mask of evil habits; "those arms folded in prayer are cutthroat weapons; they tell no beads, they slay whatever passes within range." At the sight of one of the more formidable kinds of prey the mantis gives a convulsive shiver, strikes a terrifying pose, spreads its wings, curls the tip of its abdomen, and, standing firmly on four hind legs, holds the forward part of its body upright, with forelegs forming a cross. The victim comes within range, the forelegs fall, the claws strike, and the saws clutch the prey. The wretched victim writhes with pain, chews space with its mandibles, and helplessly kicks the air. The mantids are friends of man because they live so largely on insects that are destructive to crops (see, also, page 20).

The species reproduced is: Chinese Mantis (*Tenodera sinensis* Sauss. Plate II, figure 4), an immigrant from China.

INSECT RIVALS OF THE RAINBOW

1929



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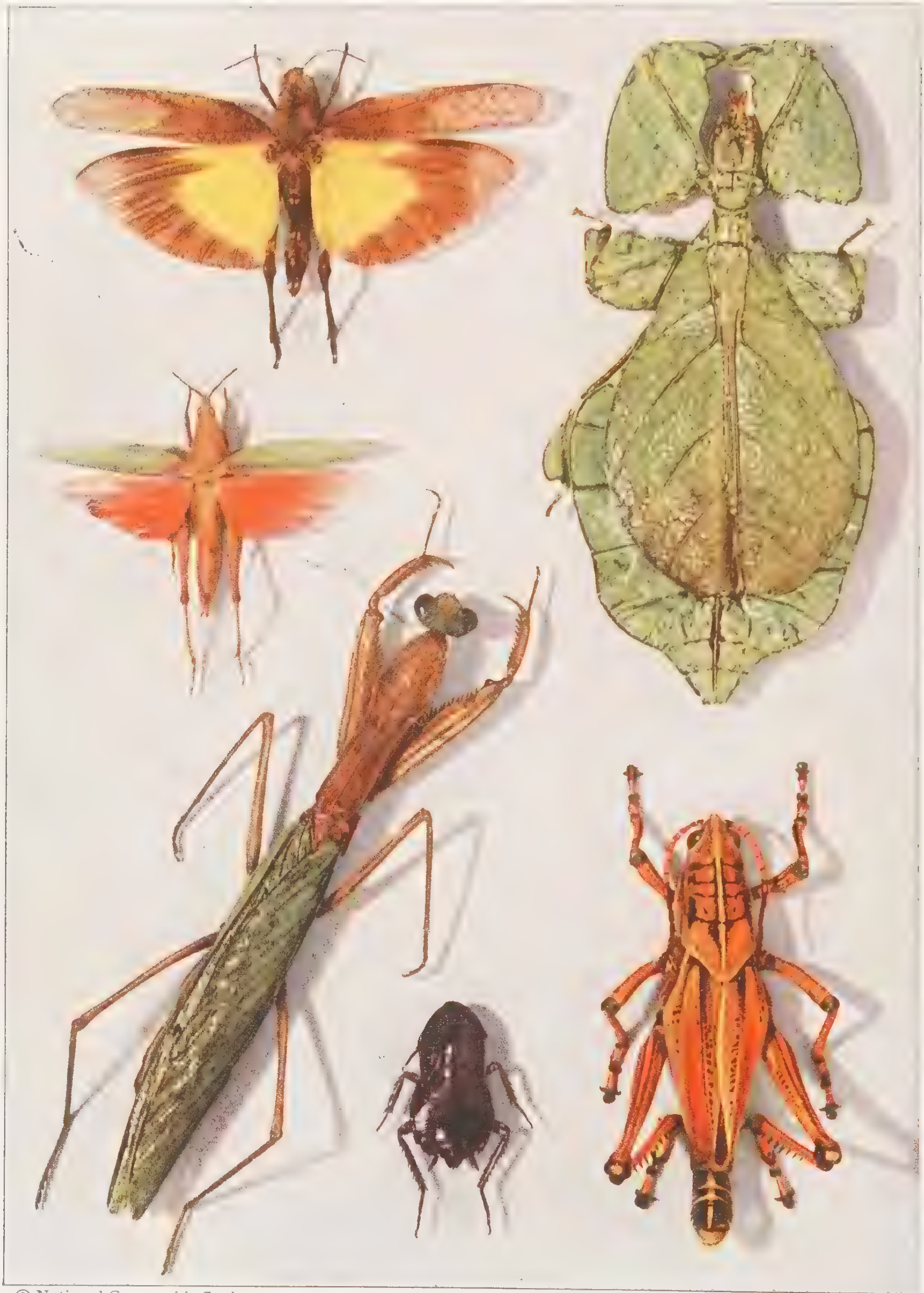
Painting by Hashime Murayama, after Paul Mĕry

SURPRISING EVENTS IN THE LIVES OF CADDIS-FLIES

Airy mannered, filmy winged, and long antennaed, one would hardly suspect the gentle creature perched on the lily as being the mother of the insectean inventor of the first submarine. She drops her eggs on the river bottom. These hatch, and the little wigglers build themselves cases of fiber and pebbles, which they line with silk. In these they can rise or sink at will. The diving beetle preys upon them as shown. The caddis-fly illustrated belongs to the family *Limnophilidae*, and the diving beetle to the family *Hydrophilidae*. The insects illustrated are natural size.



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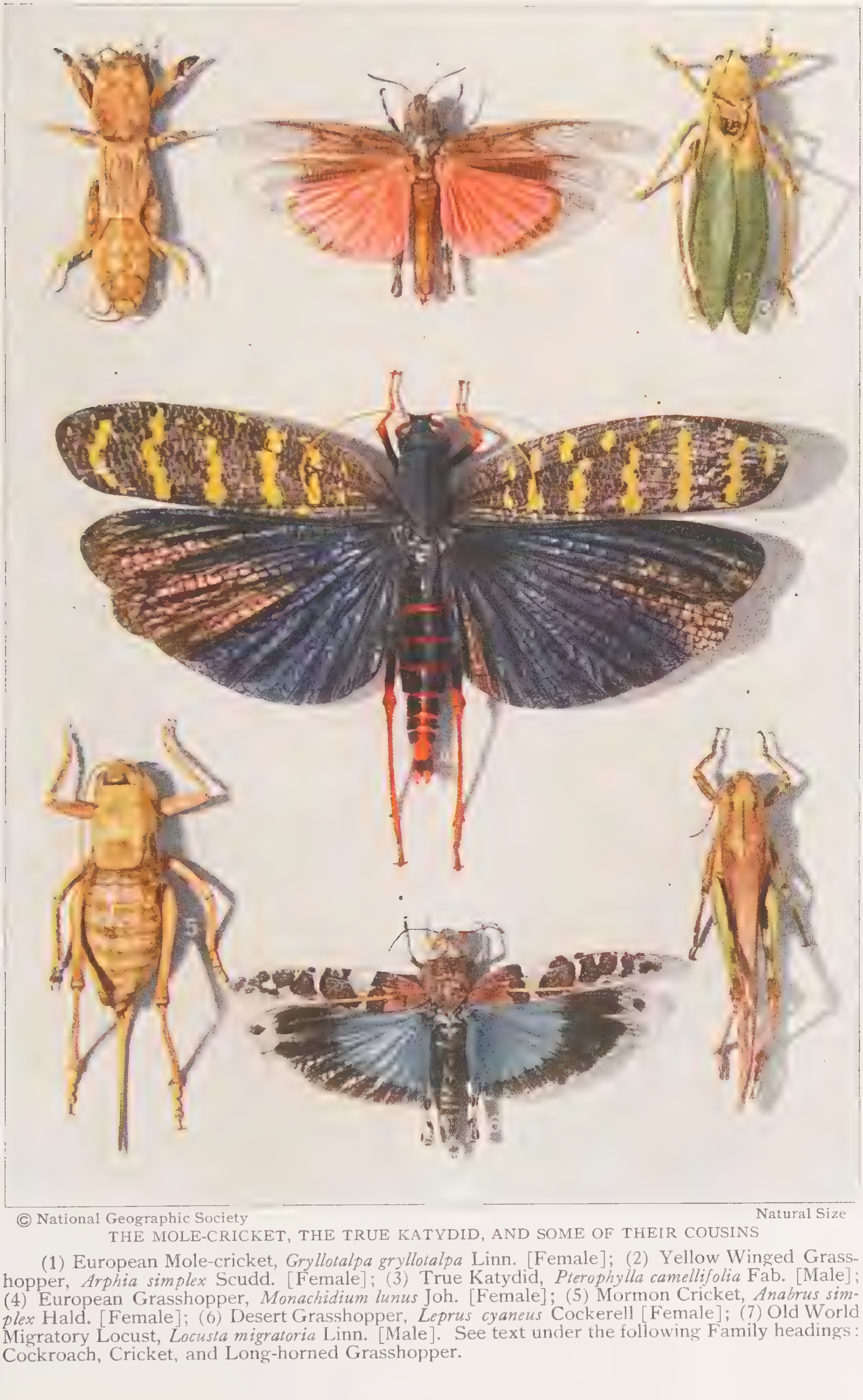
Natural Size

A GROUP OF GRASSHOPPERS AND THEIR CONTRASTING KIN

(1) Autumn Yellow Winged Grasshopper, *Arphia xanthoptera* Burm. [Female]; (2) African Grasshopper, *Atractomorpha aberrans* Karsch [Female]; (3) Walking Leaf, *Pulchriphyllium bioculatum* Gray [Female]; (4) Chinese Mantis, *Tenodera sinensis* Sauss. [Female]; (5) Oriental Cockroach, *Blatta orientalis* Linn. [Female]; (6) Eastern Lubber Grasshopper, *Romalea microptera* Palis. [Male]. See text under the following Family headings: Short-horned Grasshopper, Walking Stick, and Mantis.



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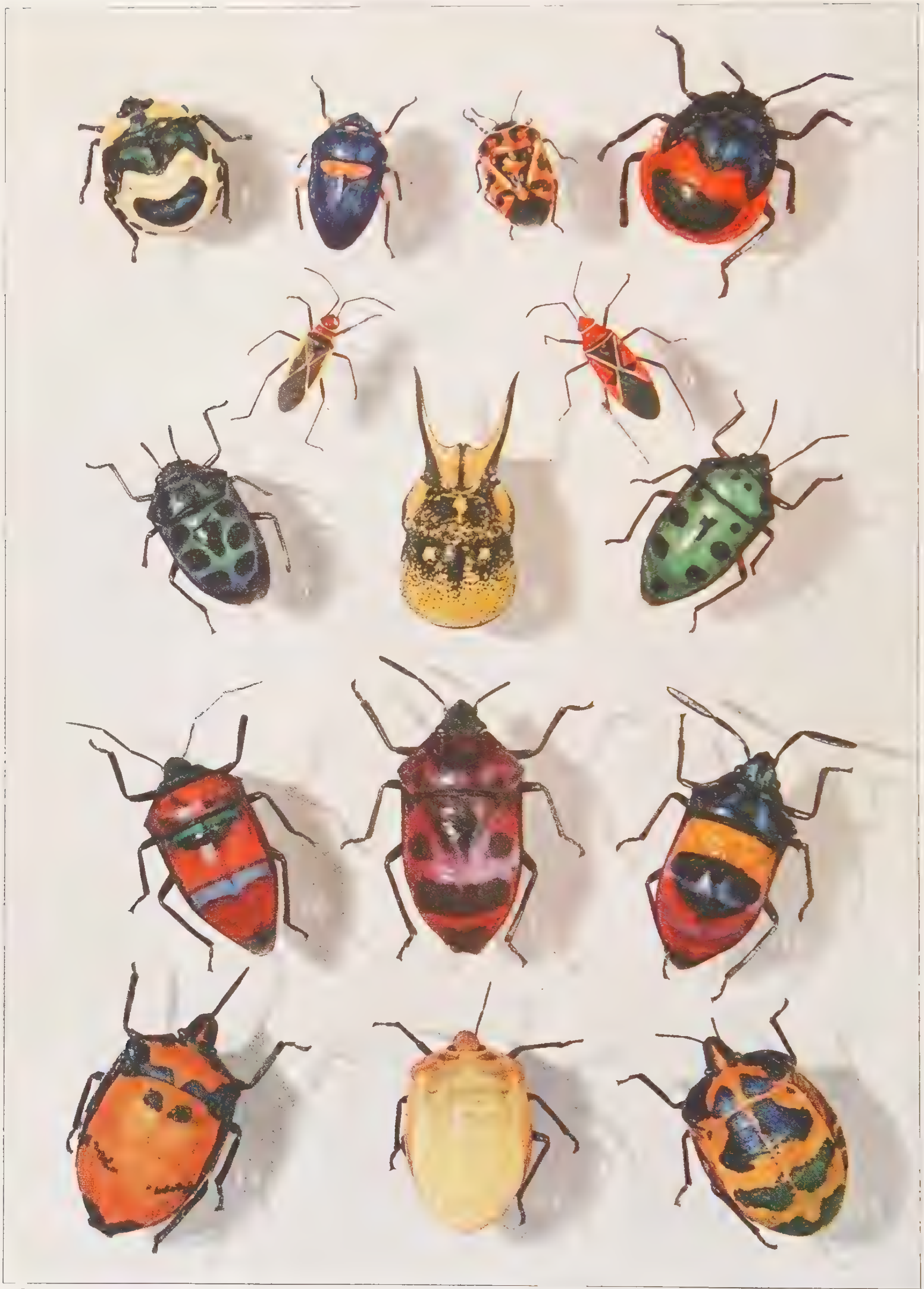
Natural Size

THE MOLE-CRICKET, THE TRUE KATYDID, AND SOME OF THEIR COUSINS

(1) European Mole-cricket, *Gryllotalpa gryllotalpa* Linn. [Female]; (2) Yellow Winged Grasshopper, *Arphia simplex* Scudd. [Female]; (3) True Katydid, *Pterophylla camellifolia* Fab. [Male]; (4) European Grasshopper, *Monachidium lunus* Joh. [Female]; (5) Mormon Cricket, *Anabrus simplex* Hald. [Female]; (6) Desert Grasshopper, *Leprus cyaneus* Cockerell [Female]; (7) Old World Migratory Locust, *Locusta migratoria* Linn. [Male]. See text under the following Family headings: Cockroach, Cricket, and Long-horned Grasshopper.



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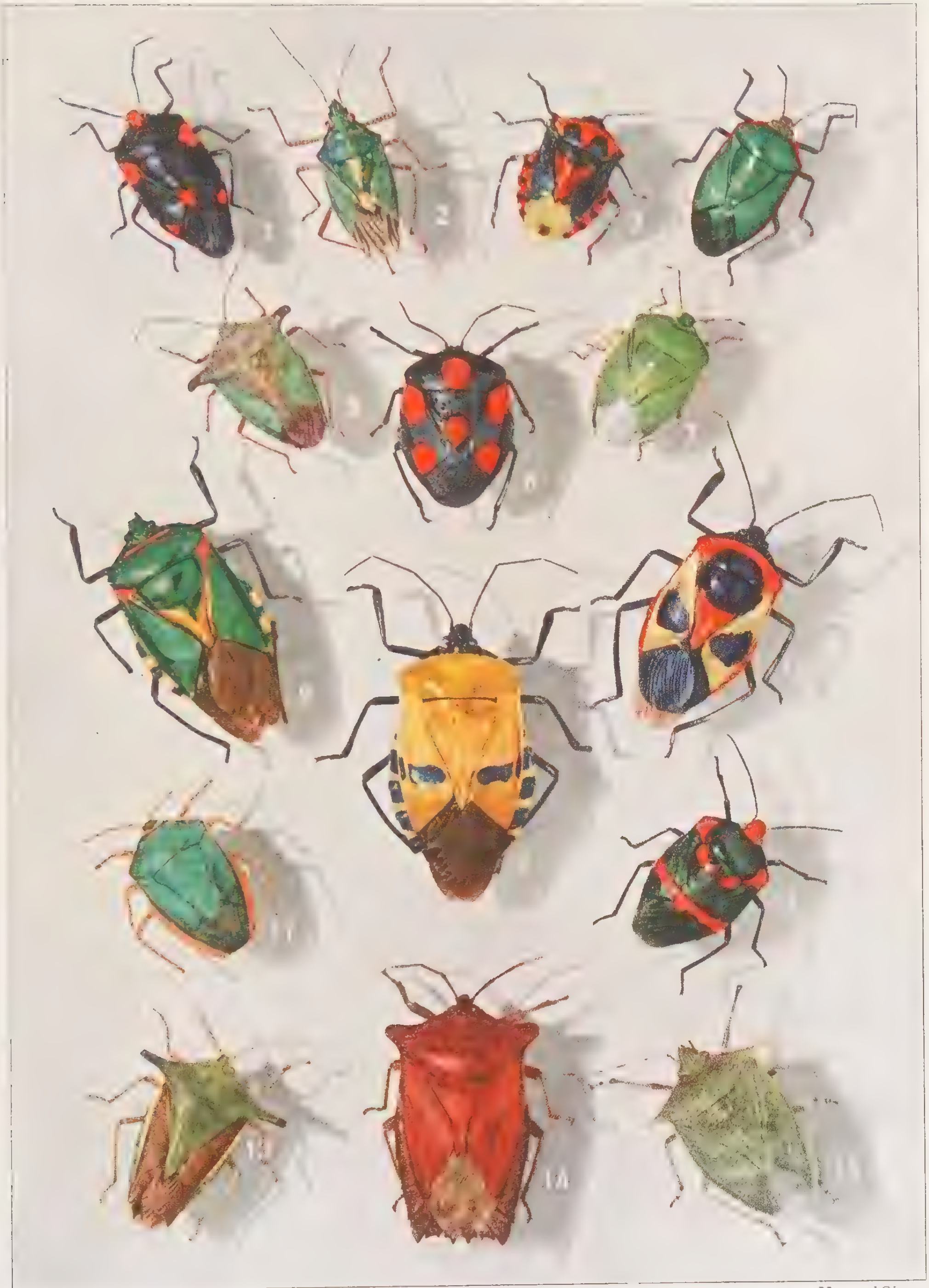
$1\frac{3}{8}$ times Natural Size

A PLATE OP HEMIPTEROUS JEWELS GATHERED FROM THE ENDS OF THE EARTH

(1) Nymph of *Poecilocoris druraei* Linn.; (2) *Philia senator* Fab. [Female]; (3) Harlequin Cabbage-bug, *Murgantia histrionica* Hahn [Female]; (4) Nymph of *Poecilocoris nepalensis* H-S.; (5) *Dysdercus mimus* Say [Male]; (6) *Dysdercus andreae* Linn. [Male]; (7) *Chrysocoris bilunulatus* Vollen. [Female]; (8) *Ceratocoris bucephalus* White [Male]; (9) *Calliphara nobilis* Linn. [Female]; (10) *Calliphara excellens* Burm. [Female]; (11) *Chrysocoris grandis* Thumb. [Female]; (12) *Chrysocoris sellatus* White [Female]; (13) *Tectocoris diopthalmus* var. *schonherri* Esch. [Female]; (14) *Tectocoris diopthalmus* var. *cyanipes* Fab. [Female]; (15) *Tectocoris peregrina* Kirk. [Female]. See text under the following Family headings: Shield-bug, Stink-bug, Cotton-stainer, and Burrowing-bug.



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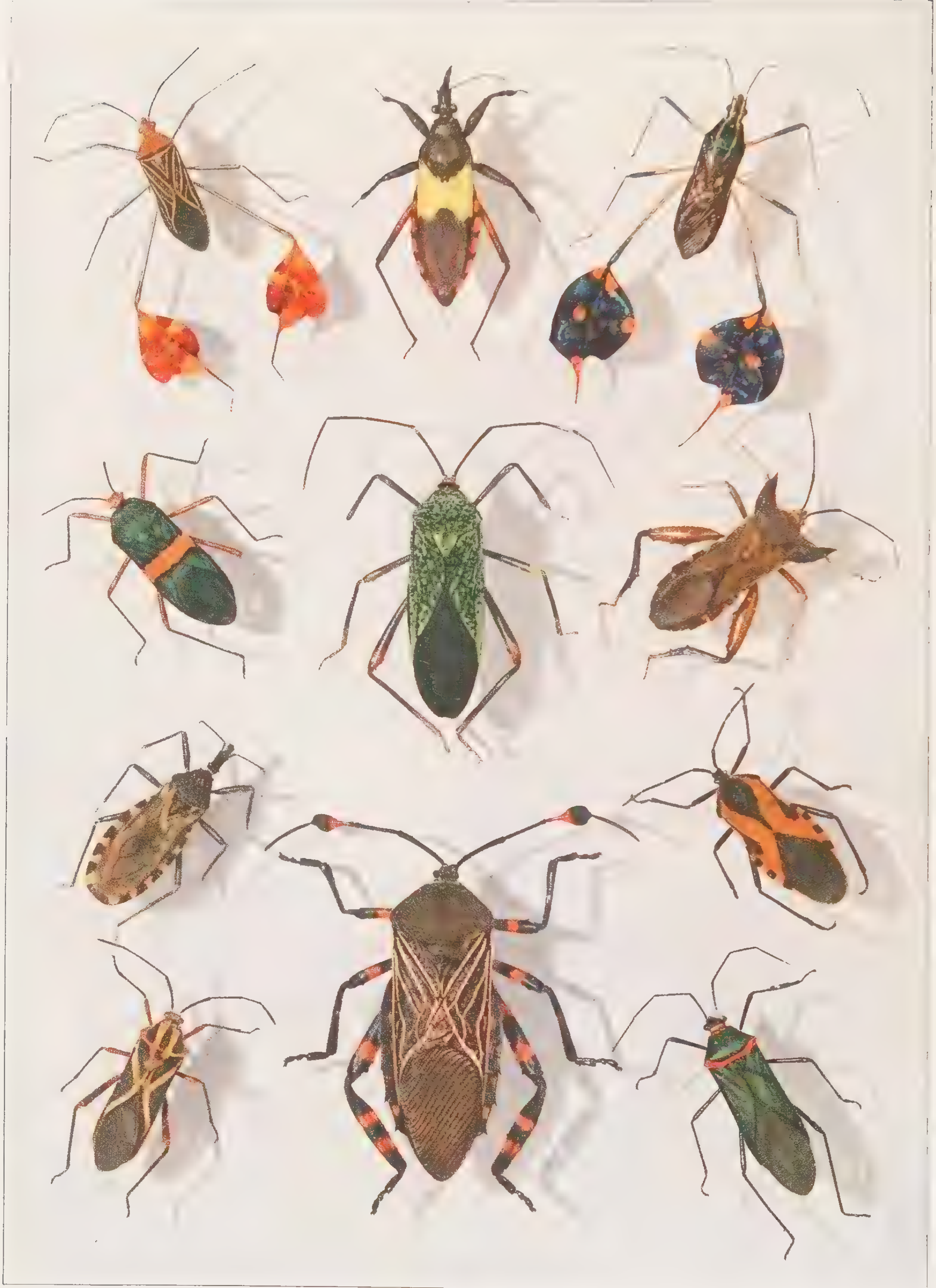
Natural Size

SOME BEAUTIFUL MEMBERS OF AN ODOROUS CLAN—THE STINK-BUGS

(1) *Arocera elongata* Uhler [Female]; (2) *Dalpada oculata* Fab. [Female]; (3) *Vulsirea violacea* Fab. [Female]; (4) *Arocera splendens* Blanch. [Male]; (5) *Edessa haedina* Stal. [Male]; (6) *Brachystethus rubromaculatus* Dallas [Female]; (7) *Nezara hilaris* Say [Female]; (8) *Chalcocoris rutilans* Stoll [Male]; (9) *Catacanthus incarnatus* Drury [Female]; (10) *Catacanthus carrenoi* LeGuill. [Female]; (11) *Edessa rufomarginata* DeGeer. [Male]; (12) *Pharypia pulchella* Stoll [Female]; (13) *Edessa cervus* Stoll [Female]; (14) *Pygoplatys longiceps* Stal. [Female]; (15) *Loxa variegata* Dist. [Male]. See text under the heading of Stink-bug Family.



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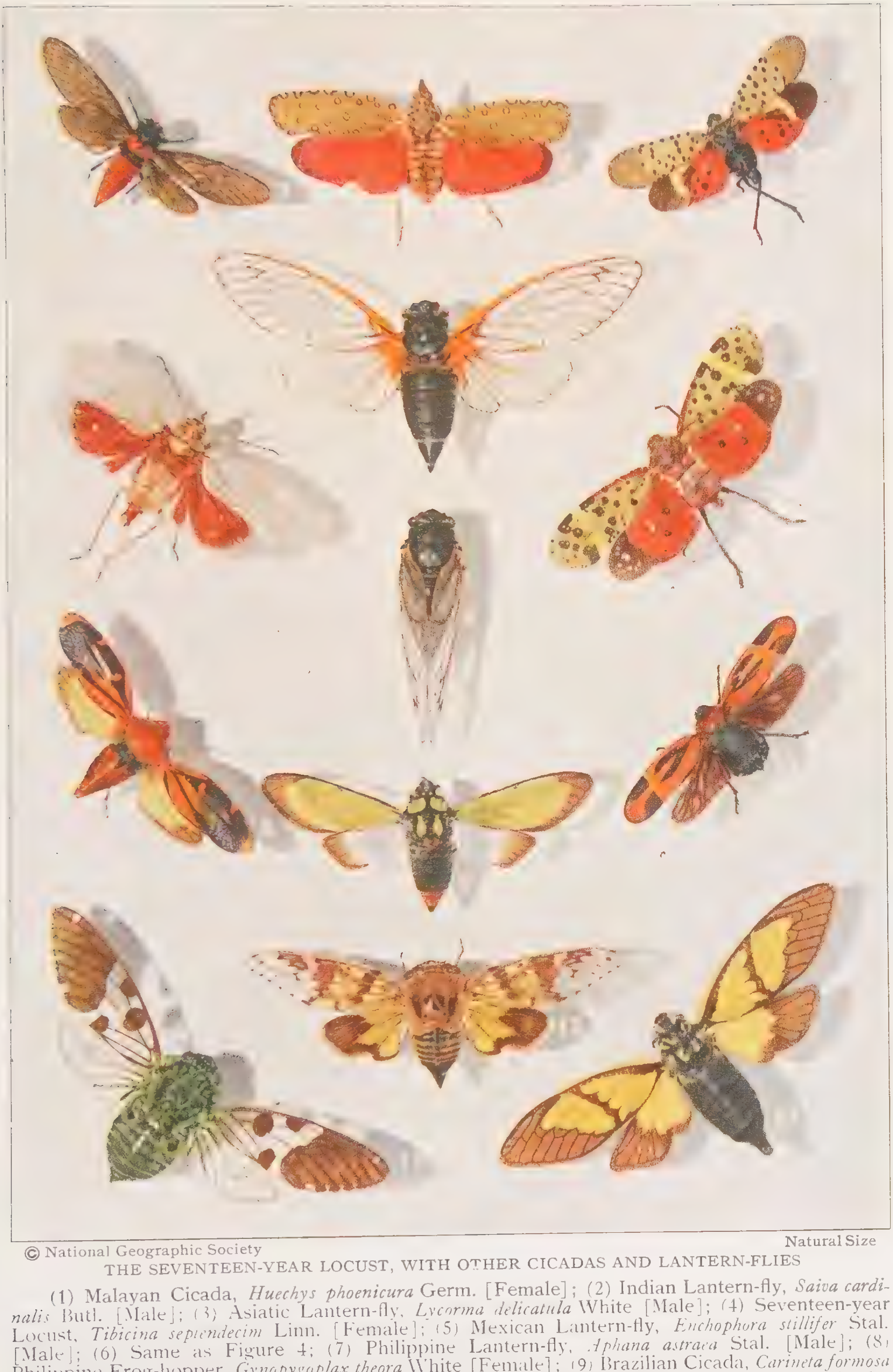
Natural Size

ASSASSIN-BUGS AND SQUASH-BUGS THAT BELIE THEIR NAMES

(1) *Anisosceles hymeniphera* Westwood [Female]; (2) *Microtomus purcis* Drury [Male]; (3) *Diactor bilineatus* Fab. [Male]; (4) *Paryphes laetus* Fab. [Female]; (5) *Mictis metallica* Sign. [Female]; (6) *Mozena lunata* Burm. [Male]; (7) *Triatoma infestans* Klug [Male]; (8) *Sephina vinula* Stal. [Male]; (9) *Machtima mexicana* Stal. [Female]; (10) *Thasus gigas* Burm. [Male]; (11) *Sphictyrtus longirostris* Dist. [Female]. See text under the following Family headings: Squash-bug and Assassin-bug. To the Assassin-bug Family belong two species which figured prominently in the news of several decades ago. They were called the kissing bugs and their reputation spread so far and wide that wherever anyone was bitten by an insect of any kind the inference was that he or she had been the victim of an attack by one of the Assassins.



Natural Size

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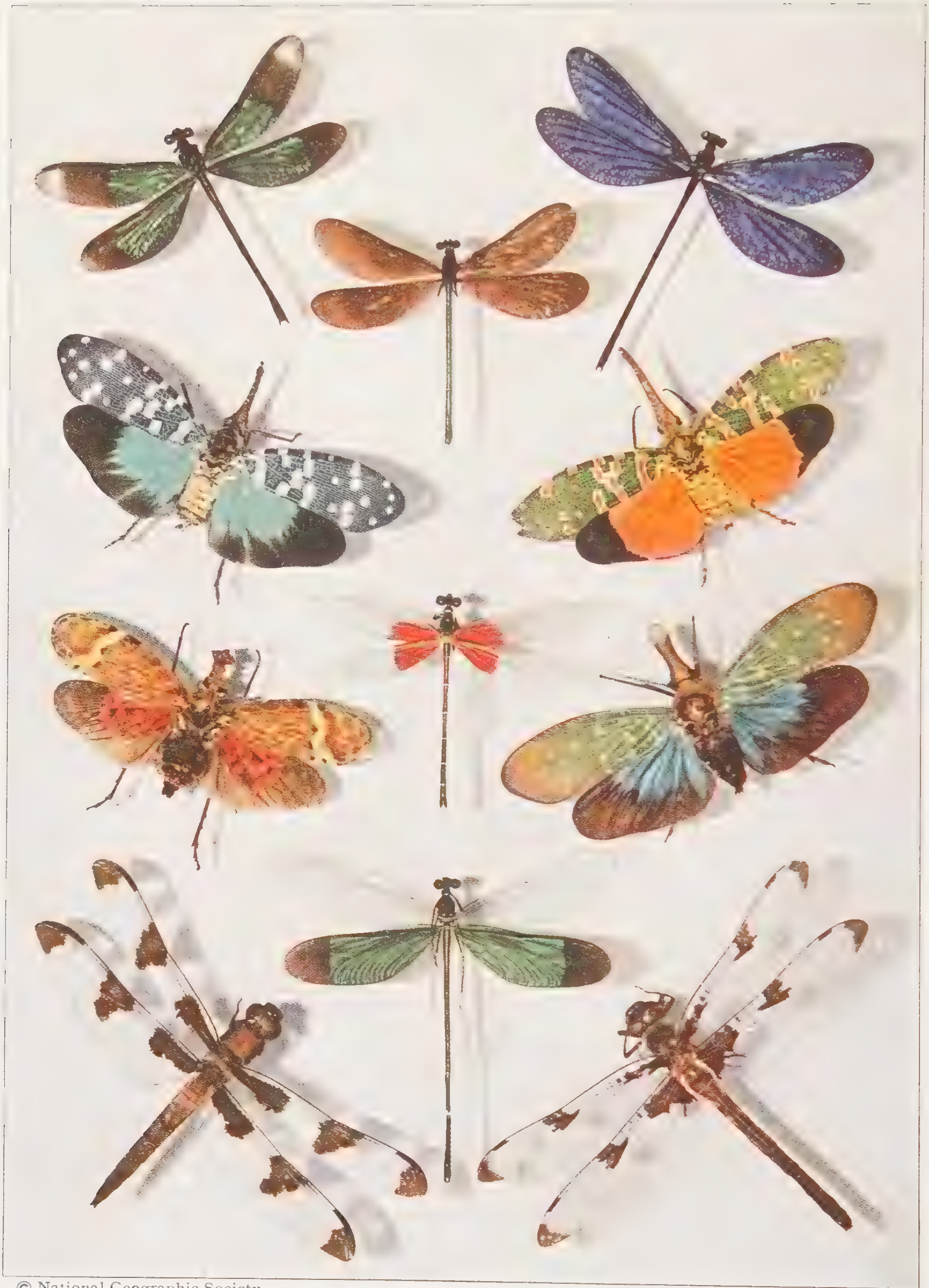
THE SEVENTEEN-YEAR LOCUST, WITH OTHER CICADAS AND LANTERN-FLIES

(1) Malayan Cicada, *Huechys phoenicura* Germ. [Female]; (2) Indian Lantern-fly, *Saiva cardinalis* Butl. [Male]; (3) Asiatic Lantern-fly, *Lycorma delicatula* White [Male]; (4) Seventeen-year Locust, *Tibicina septendecim* Linn. [Female]; (5) Mexican Lantern-fly, *Enchophora stillifer* Stal. [Male]; (6) Same as Figure 4; (7) Philippine Lantern-fly, *Aphana astraea* Stal. [Male]; (8) Philippine Frog-hopper, *Gynopygoplax theora* White [Female]; (9) Brazilian Cicada, *Carineta formosa* Germ. [Male]; (10) Brazilian Frog-hopper, *Tomaspis furcata* Germ. [Female]; (11) Mexican Cicada, *Zammara calochroma* Walk. [Male]; (12) Javanese Cicada, *Platypleura fulvigera* Walk. [Female]; (13) Indian Cicada, *Gaeana sulphurea* Hope [Male]. See text under the following Family headings: Cicada, Lantern-fly, and Frog-hopper.



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Four-fifths Natural Size

ANIMATED PURSUIT PLANES AND WINGED CLOWNS OF THE INSECT WORLD

(1) Philippine Damsel-fly, *Pseudophaea refulgens* Selys; (2) Black-wing Damsel-fly, *Agrion maculatum* Beauv.; (3) *Vestalis melania* Selys; (4) *Fulgora maculata* Olivier [Male]; (5) Chinese Candle Fly, *Fulgora candelaria* Fab. [Male]; (6) Panama Lantern-fly, *Phrictus tripunctata* Dist. [Male]; (7) Ruby-spot, *Hetaerina americana* Fab. [Male]; (8) Duck Billed Lantern-fly, *Fulgora samarana* Baker [Female]; (9) Ten Spot Skimmer, *Libellula pulchella* Drury; (10) *Neurobasis chinensis* Linn.; (11) Water-prince, *Epicordulia princeps* Hagen. The pursuit planes belong to the Dragon-fly and True Damsel-fly Families and the clowns to the Lantern-fly Family. See text under these Family headings.

Cockroach Family (*Blattidae*). Though a thousand species of cockroaches have been described, most of them inhabit tropical countries; only 43 exist north of the Rio Grande River, these usually being found in fields and woods under sticks, stones, and other rubbish. The two major pests are the Oriental Cockroach and the croton bug, both of which came from foreign parts, the former from China and the latter from Europe. Tramp steamers sometimes come into port, after sailing the seven seas, with their sailors wearing gloves when asleep, to save the nails of their hands from being gnawed off by the cockroaches.

Almost any sort of dry organic matter—paste from bookbindings or wall paper, dry bread or leather scrapings, the products of milady's larder or their own egg cases—is "beer and skittles" to the cockroach palate.

The female lays her eggs in a purselike, brown case of horny material, usually about 16 eggs in two rows, arranged so that when the young hatch, each rank will face the other. The mother cockroach, as a rule, carries the egg case with her until the babies are ready to emerge, when she assists them by tearing it open. The young ones are able, as soon as they hatch, to go about without asking odds from anybody, eating the same food as their elders enjoy. They mature in about a year, casting off a number of outgrown suits before becoming adults.

The species reproduced is: Oriental Cockroach (*Blatta orientalis* Linn. Plate II, figure 5), found in many countries.

Cricket Family (*Gryllidae*). Most of the true crickets, which belong to the Gryllid family, have developed a fondness for living close to man, and the cheery calls of the Gryllid Romeos to their Juliets are familiar sounds. They are omnivorous eaters, most species spending the day in some dark cranny and going abroad to seek their prey at night. Some species are day hunters, however. The mole-cricket leads a burrowing life, usually in damp earth. The female deposits from 200 to 300 eggs in masses of from 40 to 60. She is one of the few nonsocial insects that look after their eggs until they hatch and then feed their young until the latter are able to shift for themselves. She has to keep a sharp eye on Mr. Mole-cricket, for he does not hesitate to eat his own children when he can get hold of them.

The species reproduced is: European Mole-cricket (*Gryllotalpa gryllotalpa* Linn. Plate III, figure 1), introduced into the United States from the Old World.

Long-horned Grasshopper Family (*Tettigoniidae*). Most of the older authorities call this family the *Locustidae*. It embraces the katydids, the meadow grasshoppers, the camel crickets, the sword bearing crickets, the western crickets, and the Jerusalem crickets.

The species reproduced are: True Katydid (*Pterophylla camellifolia* Fab. Plate III, figure 3), occurring in eastern United States; Mormon Cricket (*Anabrus simplex* Hald. Plate III, figure 5), habitat western United States.

THE BUGS AND CICADAS AND THEIR RELATIVES

(Order *Hemiptera*)

Plates IV to VIII

This order is one of the most versatile in habit and form. While many recent authorities subdivide it into several groups, the more conservative older classification is used by many museums.

The group embraces about 5,000 American species, including plant-lice, scale-insects, and mealy wings; cicadas, lantern-flies, tree- and leaf-hoppers, and spittle-insects; water- boatmen, striders, and scorpions; ambush-bugs, assassin-bugs, stink-bugs, and many others.

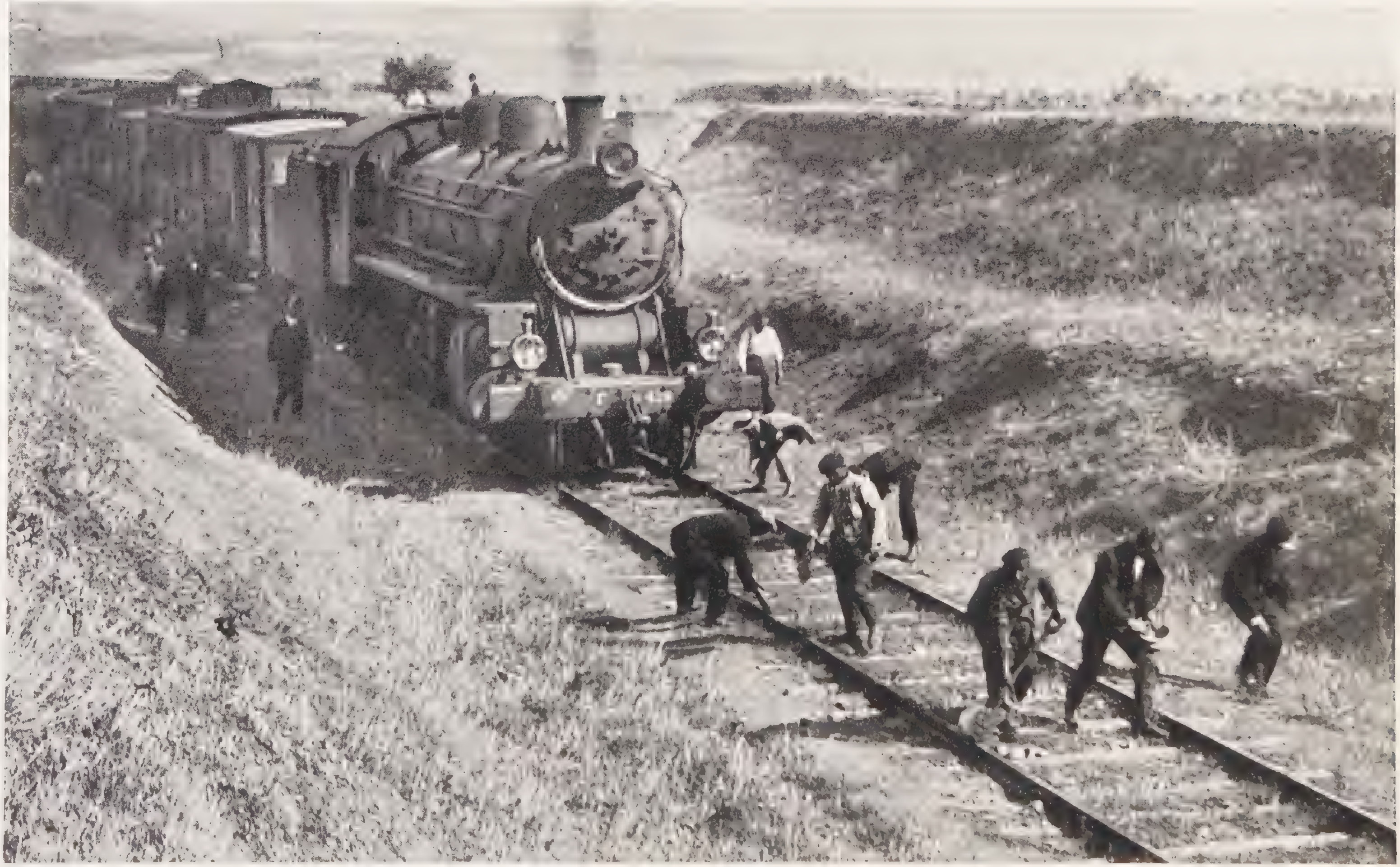
Some of the remarkable families not shown because of the minuteness of their members are those which produce plant galls. Typical of these are the sucking bugs of the plant-louse type, which produce the twig gall of the hickory and the root gall of the grape. Another is the family to which belongs the San José scale. The males of some species of this family are mouthless and so have a very brief existence. The females become both footless and blind after settling down.

Statisticians have estimated that leaf-hoppers, by sucking the sap, probably destroy one-fourth of all the grass that grows and that a million of them will kill as much forage as a cow can eat.

Shield-bug Family (*Scutelleridae*). The shield-bugs constitute an attractive clan, of which some 25 American species have been described. None of the latter occurs in sufficient numbers to be of economic importance.

The species reproduced are: Nymph of *Poecilocoris druraei* Linn. (Plate IV, figure 1), occurring in India and China; *Philia senator* Fab. (Plate IV, figure 2), occurring in Australia and Malaysia; Nymph of *Poecilocoris nepalensis* H-S. (Plate IV, figure 4), occurring in India and China; *Chrysocoris bilunulatus* Vollen. (Plate IV, figure 7), a native of Sumatra; *Calliphara nobilis* Linn. (Plate IV, figure 9), habitat southeastern Asia; *Calliphara excellens* Burm. (Plate IV, figure 10), occurring in southeastern Asia; *Chrysocoris grandis* Thumb. (Plate IV, figure 11), habitat China, Japan, and India; *Chrysocoris sellatus* White. (Plate IV, figure 12), a native of the Philippines; *Tectocoris diopthalmus* var. *schonherri* Esch. (Plate IV, figure 13), habitat extending from the coast of China to that of Australia; *Tectocoris diopthalmus* var. *cyanipes* Fab. (Plate IV, figure 14), a native of Java; *Tectocoris peregrina* Kirk. (Plate IV, figure 15), inhabiting the lands that border the Indian Ocean.

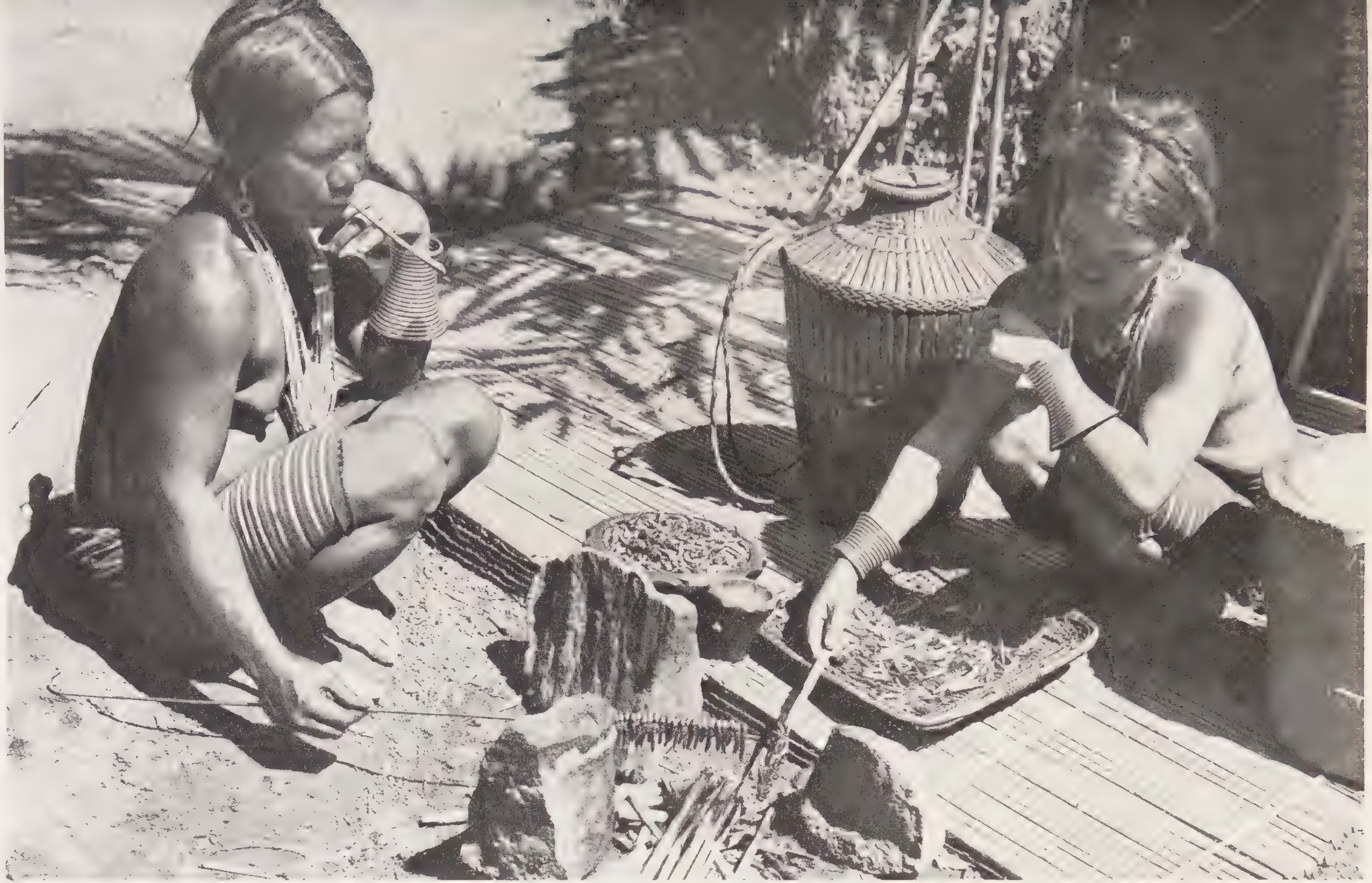
Stink-bug Family (*Pentatomidae*). This family comprises some 4,000 species, about 300 occurring in the United States. Most species



Photograph by Ewing Galloway

LOCUSTS HOLD UP A FREIGHT TRAIN ON THE ATHENS-SALONIKI LINE

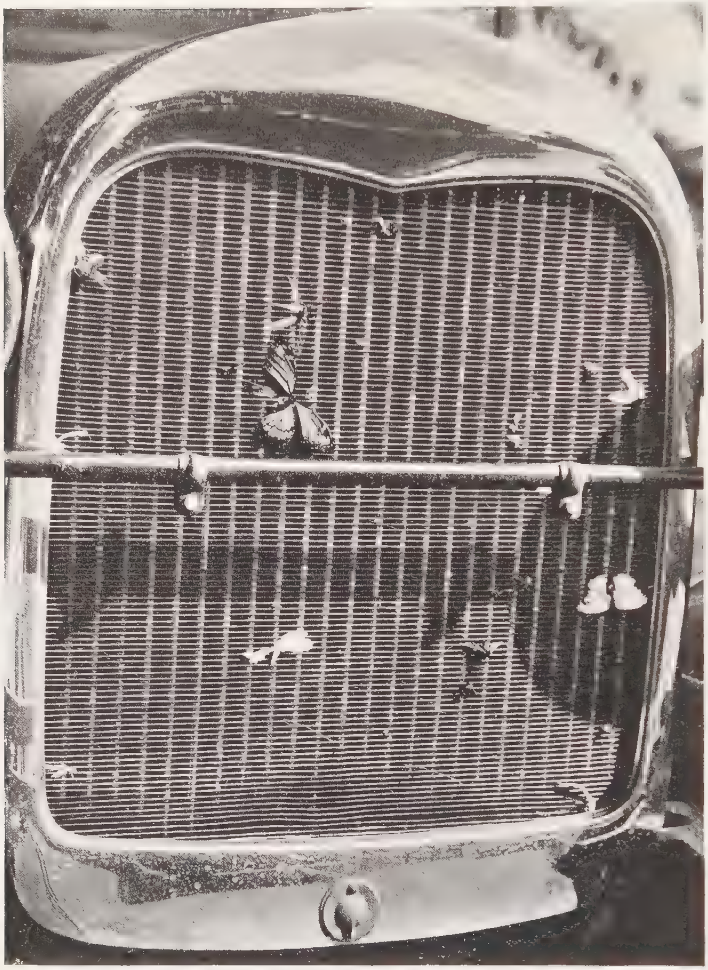
The locusts that plagued Egypt in Bible times, the ones that figure periodically in the devastation of Palestine, those that made Kansas the "hopper" State some decades ago, and those which from time to time descend on the Argentine pampa and transform luxuriant vegetation into a desert waste, are all of a pattern. They belong to the short-horned grasshopper family. A train cannot get traction on rails that have been "soaped" with the crushed bodies of these insects.



Photograph by Charles Martin

LOCUSTS AND WILD HONEY STILL REMAIN FOOD ITEMS AMONG PRIMITIVE PEOPLE

Ifugao women in Luzon, Philippine Islands, prepare locusts for food by roasting them. Such rich feasts often cause indigestion. According to Mosaic law (Leviticus 11, 22), the Children of Israel were permitted to eat "the locust after his kind, and the beetle after his kind, and the grasshopper after his kind." Flies and fly eggs are made into cakes by some Indian tribes in Mexico, and some species of beetles are used to put more "kick" in certain types of alcoholic beverages drunk by other tribes in the same country (see text, page 9).



Photograph by Clifton Adams

AN ILLUSTRATION OF ONE OF THE MEANS BY WHICH INJURIOUS INSECTS MAY BE DISTRIBUTED BY MAN UNWITTINGLY

Several insects occurring in south Florida caught in the radiator of an automobile. Some flew into the path of the car and some were drawn in by the draft of the motor-cooling fan.

are plant feeders, but not a few are omnivorous. Several of the more common American stink-bugs are green, like the large green tree bug and the bound tree bug; other common species are brown.

A few of the American species are as bizarre in their dress as a clown, and it is this character of its coat that gives to one of our worst pests, the Harlequin Cabbage-bug, its everyday name. That insect also might be regarded as the beer bug, for its eggs, neatly arranged in groups of twelve, six in a row, look like a group of miniature beer kegs, even down to the hoops and the bung.

The species reproduced are: Harlequin Cabbage-bug (*Murgantia histrionica* Hahn. Plate IV, figure 3), habitat United States; *Arocera elongata* Uhler. (Plate V, figure 1), habitat Brazil; *Dalpada oculata* Fab. (Plate V, figure 2), occurring in India, China, and Japan; *Vulsirea violacea* Fab. (Plate V, figure 3), ranging from Mexico to Brazil; *Arocera splendens* Blanch. (Plate V, figure 4), native of Central America and the northern part of South America; *Edessa haedina* Stal. (Plate V, figure 5), native of Mexico; *Brachystethus rubromaculatus* Dallas. (Plate V, figure 6), inhabiting Central America and Mexico; *Nezara hilaris* Say. (Plate V, figure 7), occurring in the United States; *Chalcocoris rutilans* Stoll. (Plate V, figure 8), habitat Africa; *Catacanthus incarnatus* Drury. (Plate V, figure 9), occurring in Japan, China, and Borneo; *Catacanthus carrenoi LeGuill.* (Plate V, figure 10), a native of the Philippines; *Edessa rufomarginata* DeGeer. (Plate V, figure 11), ranging from Mexico to the Argentine; *Pharypia pulchella* Stoll. (Plate V, figure 12), ranging from Mexico south to Brazil; *Edessa cervus* Stoll. (Plate V, figure 13), habitat Brazil to northern South America; *Pygoplatys longiceps* Stal. (Plate V, figure 14), occurring in the Philippines; *Loxa variegata* Dist. (Plate V, figure 15), occurring in Costa Rica and Panama.

Cotton-stainer Family (*Pyrrhocoridae*). This family is represented in our fauna by 22 species, which sometimes are known as redbugs. The cotton-stainers do much damage by piercing cotton stems and bolls with their beaks and sucking the sap. Their principal damage, however, comes from the staining of the cotton in its open boll by the insects' excretions. Some species attack oranges, puncturing the skin and thereby causing the fruit to decay and fall to the ground.

The species reproduced are: *Dysdercus mimus* Say. (Plate IV, figure 5), occurring in the South; *Dysdercus andreae* Linn. (Plate IV, figure 6), occurring in Florida and the West Indies.

Burrowing-bug Family (*Cydnidae*). Twenty-nine species of this family now are listed in the United States. Their front legs are more or less flattened and fitted for digging, and they are found burrowing in sandy places and under sticks and stones. It is thought that they feed by sucking the sap from plant roots.

The species reproduced is: *Ceratocoris bucephalus* White. (Plate IV, figure 8), habitat southeastern Asia.

Squash-bug Family (*Coreidae*). This family consists of some 1,500 known species, of which 200 are American. The familiar squash-bug is its most widely known representative. To it also belong the box elder bug, which sucks the sap of the box elder and in adulthood resembles a giant bed-bug, and the cherry bug, which imbibes the juice of the cherry.

Some of the squash-bugs are queer-looking "critters." One has its wing cases higher at the sides than at the middle, thus producing a sort of hopper with a series of spines around the edge. In this the male has to carry the family eggs, but he accepts his task only after his spouse has henpecked him to a point where he sees that opposition is useless.

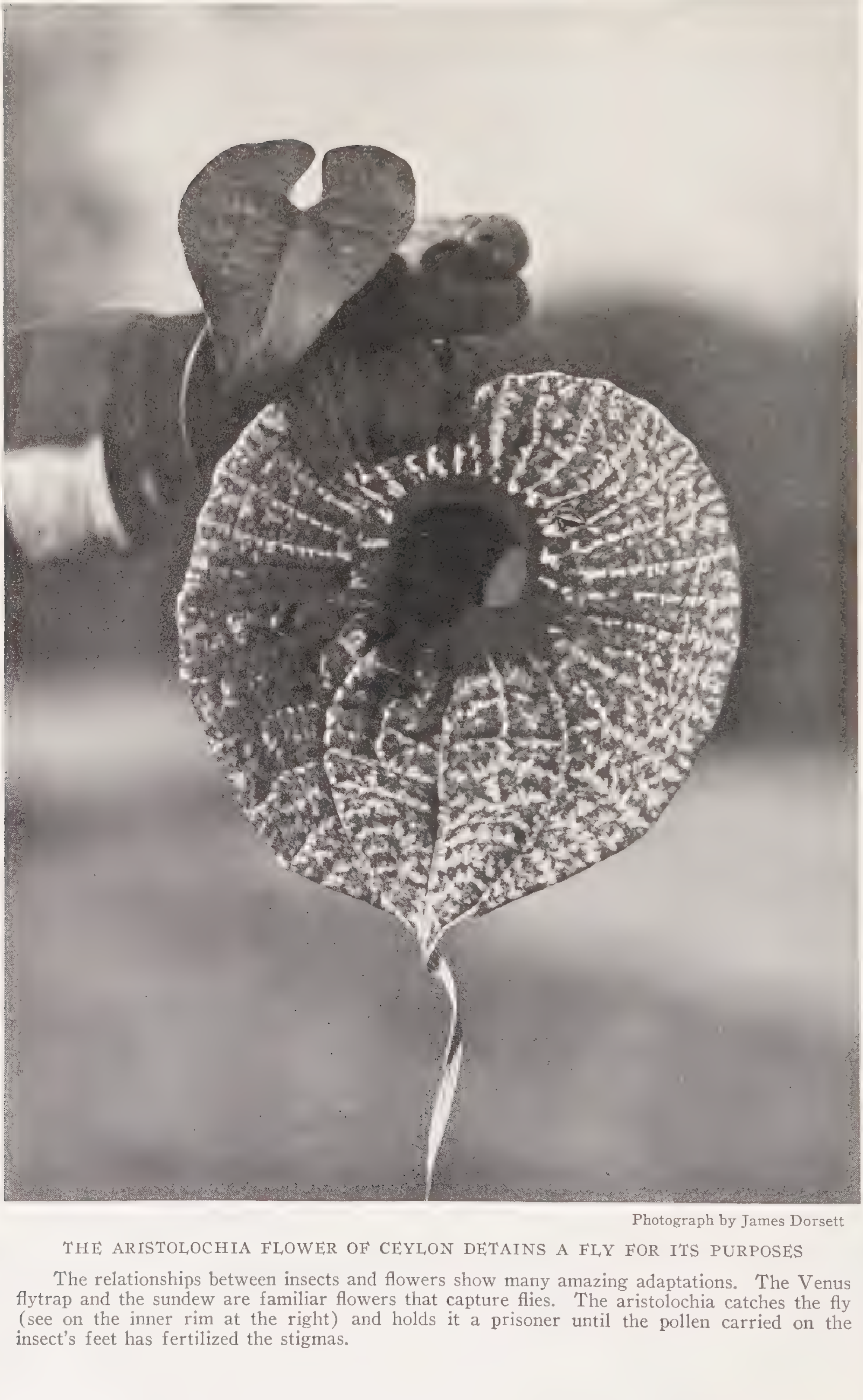
The species reproduced are: *Anisosceles hymeniphera* Westwood. (Plate VI, figure 1), found in Mexico; *Diactor bilineatus* Fab. (Plate VI, figure 3), inhabiting northern South America; *Paryphes laetus* Fab. (Plate VI, figure 4), occurring throughout South America; *Mictis metallica* Sign. (Plate VI, figure 5), native of Africa; *Mozena lunata* Burm. (Plate VI, figure 6), ranging from Texas to Central America; *Sephina vinula* Stal. (Plate VI, figure 8), inhabiting Mexico; *Machtima mexicana* Stal. (Plate VI, figure 9), habitat Mexico and Central America; *Thasus gigas* Burm. (Plate VI, figure 10), frequenting the southwestern part of the United States and Mexico; *Sphictyrtus longirostris* Dist. (Plate VI, figure 11), occurring in Central America.

Photograph by Charles Martin

AN IFUGAO LOCUST CATCHER WITH HIS NET, IN LUZON

Locusts sometimes swarm in unbelievable numbers. In 1889 a vast army of them spread out over an area of more than 2,000 square miles, while flying over the Red Sea. Cyprus reported an invasion in 1881 during which 1,300 tons of eggs alone were destroyed.

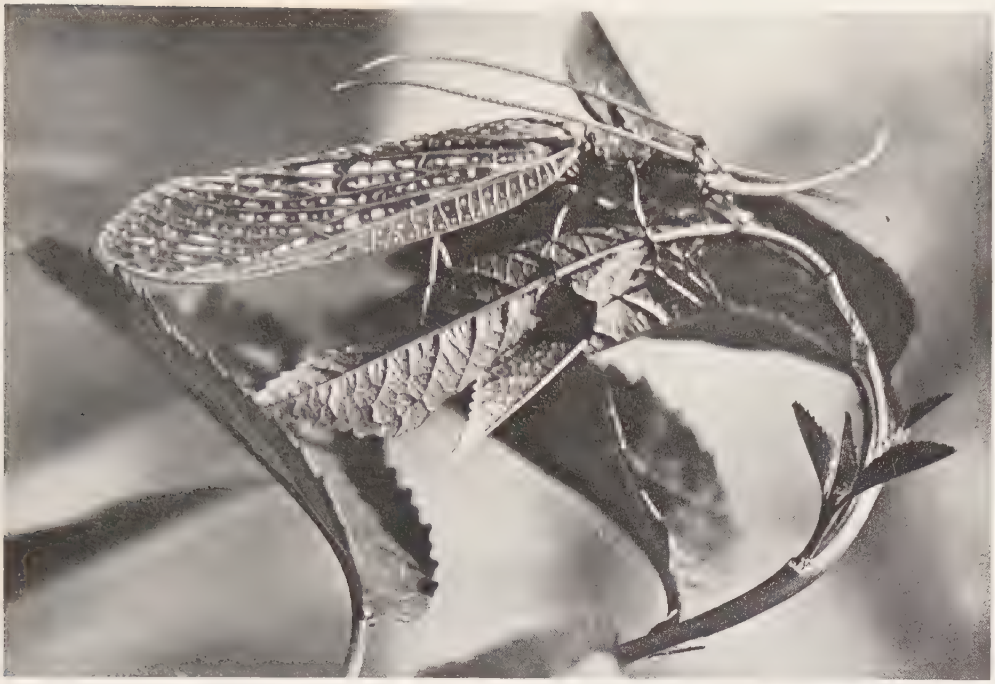
Assassin-bug Family (*Reduviidae*). This family, embracing some 2,000 species, most of them predaceous, feeds principally on the juices of other insects, draining the prey dry. To it belongs the famous kissing bug of yesteryear, whose young have coats of bristly, sticky hairs to which dust adheres, making a sort of mask from which its other name, masked bed-bug hunter, is derived. It is able to bite hard, inflicting a rather painful wound. Rarely, however, does it bite human beings unless attacked. Usually living out-of-doors, it sometimes invades vermin-haunted houses. In the South lives another member of the family known as the big bed-bug, which is a persistent sucker of human blood, and therefore is frequently rated as a kissing bug. The wheel-bug has a toothed



Photograph by James Dorsett

THE ARISTOLOCHIA FLOWER OF CEYLON DETAINS A FLY FOR ITS PURPOSES

The relationships between insects and flowers show many amazing adaptations. The Venus flytrap and the sundew are familiar flowers that capture flies. The aristolochia catches the fly (see on the inner rim at the right) and holds it a prisoner until the pollen carried on the insect's feet has fertilized the stigmas.



Photograph by Leonard Sefing

A HELLGRAMMITE FLY FINDS SAFETY IN MIMICRY

Before man ever dreamed of a World War, insects had come to be masters of the art of camouflage. Some of them employ fearsome aspects, others have acquired a low visibility, and still others imitate creatures that possess qualities distasteful to their natural enemies. The hellgrammite merges itself into its environment so that only sharp eyes detect its presence.

crest resembling a cock's comb on its thorax, and its eggs are shaped like little jugs, laid in masses of about 70.

The species reproduced are: *Microtomus purcis* Drury. (Plate VI, figure 2), inhabiting the southeastern United States; *Triatoma infestans* Klug. (Plate VI, figure 7), occurring in South America.

Cicada Family (*Cicadidae*). About 74 species of this family are found in our fauna, including the harvest-flies and lyremen. The most famous cicada, however, is the Seventeen-year Locust. Of all known insects it has the longest period of adolescence, spending 17 years under the ground in its larval stage and only a few weeks awing in its adult form.

Emerging from the ground after throwing off its larval clothes, it makes merry for a few days and then dies. In laying her eggs the female pierces the twigs of various trees, and in the slit thus made deposits them. These twigs later break and fall to the ground, and in about six weeks the young hatch and creep down beneath the surface to begin their long subterranean career. They feed on the humus in the soil and, to some extent, on the juices of the roots of trees and other deep-soil plants, and molt from four to six times during their underground life.

The species reproduced are: Malayan Cicada (*Huechys phoenicura* Germ. Plate VII, figure 1), occurring in the Malay Archipelago; Seventeen-year Locust (*Tibicina septendecim* Linn. Plate VII, figures 4 and 6), inhabiting the eastern United States; Brazilian Cicada (*Carineta formosa* Germ. Plate VII, figure 9), habitat Brazil; Mexican Cicada (*Zammara calochroma* Walk. Plate VII, figure 11), habitat Mexico and South America; Javanese Cicada (*Platypleura fulvigera* Walk. Plate VII, figure 12), habitat Malay Archipelago; Indian Cicada (*Gaeana sulphurea* Hope. Plate VII, figure 13), occurring in India.

Lantern-fly Family (*Fulgoridae*). While most of our lantern-flies are small, many of the tropical species are large and bizarre. Someone has said that their growth has gone to their heads. A Brazilian species looks something like an insectean hippopotamus, there being even the simulation of tusks on its dangerous-looking, but wholly innocent, head. Certain species of lantern-flies in China excrete large quantities of white, flocculent wax, which is used by the Chinese for candles and other purposes.

The species reproduced are: Indian Lantern-fly (*Saiva cardinalis* Butl. Plate VII, figure 2), living in India; Asiatic Lantern-fly (*Lycorma delicatula* White. Plate VII, figure 3),

Photograph by Will F. Taylor

A BEETLE OF THE BELGIAN CONGO ROLLING A BALL OF DUNG TO ITS NEST

This is a cousin of the famous sacred beetle of the ancient Egyptians, which was placed in the tombs with the dead, whose picture was painted on sarcophagi, and whose image was carved in stones and precious gems. The familiar rose beetle belongs to the same clan.

occurring in India and China; Mexican Lantern-fly (*Enchophora stillifer* Stal. Plate VII, figure 5), from Mexico and Central America; Philippine Lantern-fly (*Aphana astraea* Stal. Plate VII, figure 7), a native of the Philippines; *Fulgora maculata* Olivier. (Plate VIII, figure 4), inhabiting Ceylon and India; Chinese Candle Fly (*Fulgora candelaria* Fab. Plate VIII, figure 5), occurring in India and China; Panama Lantern-fly (*Phrictus tripunctata* Dist. Plate VIII, figure 6), habitat Panama; Duck Billed Lantern-fly (*Fulgora samarana* Baker. Plate VIII, figure 8), occurring in the Philippines.

Frog-hopper Family (*Cercopidae*). In rural strolls occasionally one sees small masses of froth adhering to the stems of taller grasses and weeds. This is a viscid fluid whipped into a heavy froth by an insect which gets its popular name, frog-hopper, from the belief that these masses are the spittle of tree frogs (see illustration, page 22).

One familiar species, the foamy cicadella, uses the froth it creates as a sunshade. With its proboscis sunk deep into a plant stem or leaf, it sucks out the sap, which it passes through a tiny mechanism at the tip of its abdomen. In this process it mixes air and a foam-forming substance with the sap, producing tiny bubbles having a tenacity that causes them to last for many hours.

The species reproduced are: Philippine Frog-hopper (*Gynopygoplax theora* White. Plate VII, figure 8), inhabiting the Philippines; Brazilian Frog-hopper (*Tomaspis furcata* Germ. Plate VII, figure 10), occurring in Brazil.

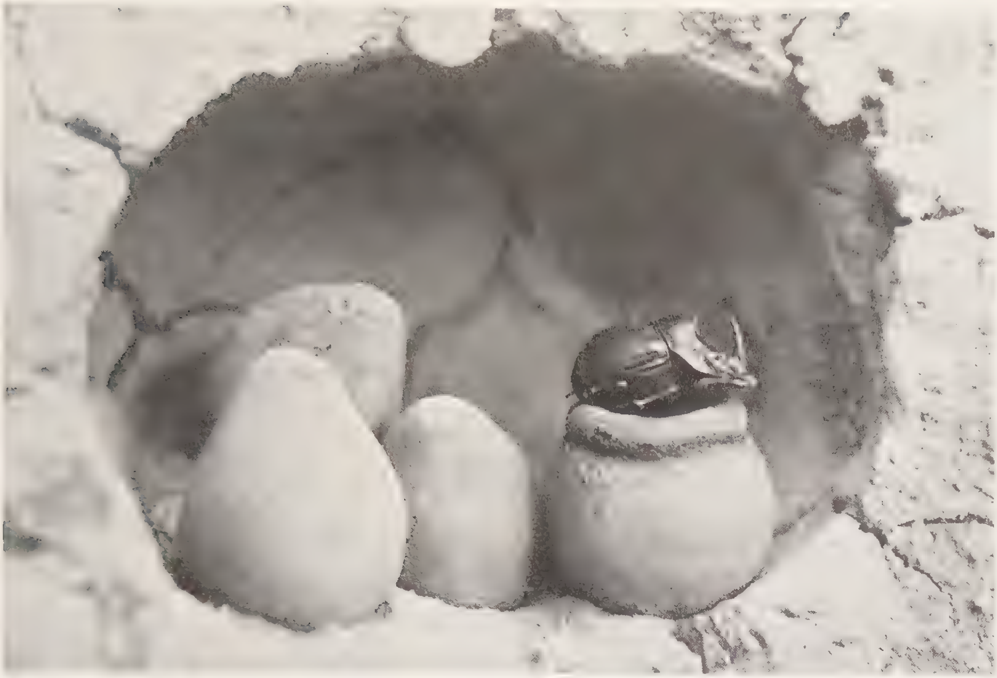
DRAGON- AND DAMSEL-FLIES

(Order *Odonata*)

Plate VIII

The creatures of this order might be called the hawks of insectdom. There are about 2,000 known species, 300 of which are found in the United States. Though bucolic superstition has it that the dragon-flies are snake doctors, that they sew up the ears of boys who wade in creeks, and that they are horse stingers and mule killers, they are, as a matter of fact, honest-to-goodness friends of everybody, since their favorite food is the pestiferous mosquito and the bothersome fly.

Compound eyes with as many as 30,000 facets are possessed by many species. These produce marvelous mosaics of images and give the possessor a wide angle of vision. Many species also have simple eyes to reënforce the powers of their compound optics. The dragon-fly's head is mounted on its body with an insectean version of a ball and socket joint, which enables the insect to see beneath and above itself—a power denied all except a few of the



Photograph by Paul Henri Fabre

A SCARAB OF SPAIN

It is one of the anomalies of Nature that, with few exceptions, the two groups of insects which show maternal solicitude for their young are the bees and the dung beetles. So intense is the affection of the latter for their children that the mother remains for four consecutive months without food, down in her burrow, looking after her brood, attending to their needs as grub, nymph, and finally as insect.

other members of the segmented, six-legged order of creatures.

In order to hold its prey, once overtaken, the dragon-fly groups its six legs together to form a basket in which the victim is clutched and held until the two front legs can get a firm grip on it. In some species the victim is eaten on the wing, in others the captor alights and eats at leisure. Most species breathe 118 times a minute as compared with the average man's 18 times. Ten pairs of breathing tubes lead from as many spiracles into the body.

The young of the damsel- and dragon-flies are wholly unlike their parents; they are aquatic. Down on the bed of a murky stream or muddy pond they dwell, thick of body, big of head, and half concealed in slime. Through their dirty, gray-green bodies they possess low visibility as they lie in ambush, waiting for some hapless creature to come their way.

When a May-fly larva, or a caddis-worm, or a water bug passes by on its unsuspecting way, the biggest mouth one ever saw on so small a creature opens wide and the luckless forager finds itself being chewed to pieces. The large lower lip effectually conceals the big mouth and sharp jaws until the prey comes by. Then the lip is extended and there shoots from the head a vicious pincerlike organ that grasps the victim and draws it in.

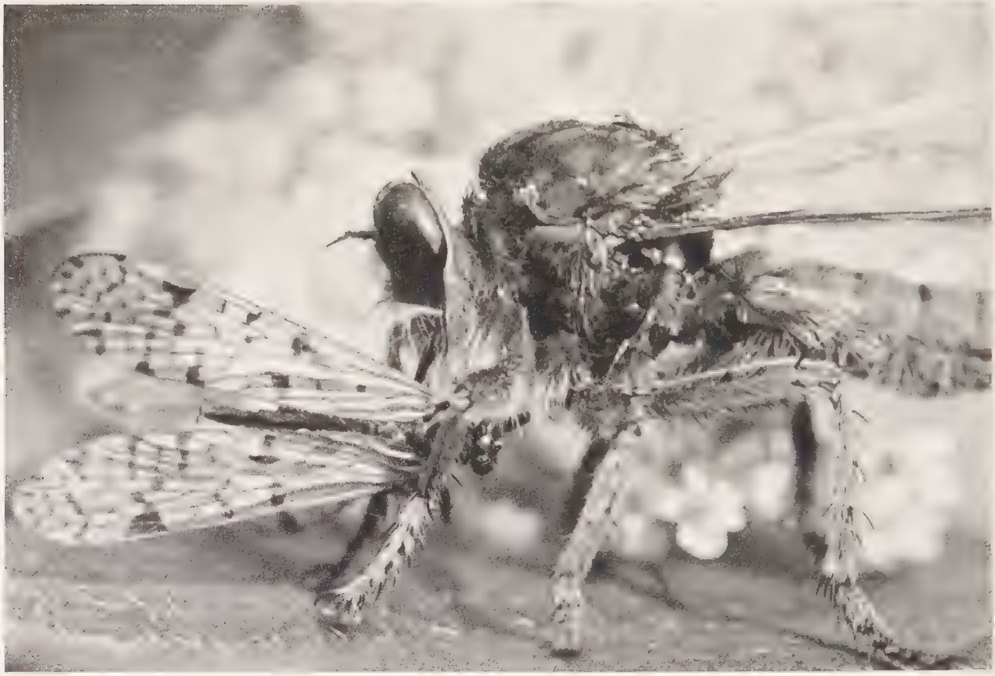
The nymphs propel themselves by drawing in and expelling drafts of water through their intestinal tracts. This expulsion is with considerable force, which, on the principle of the recoil of a gun, drives them forward a short distance.

Skimmer Family (*Libellulidae*). The dragon-flies of this family are found all over the country. The Water-prince is an unusually fine flyer and a hard creature to capture. The female flies alone when depositing her eggs, and makes her dips to the surface of the water some distance apart, so that her eggs may not be, so to speak, "all in one basket."

The species reproduced are: Ten Spot Skimmer (*Libellula pulchella* Drury. Plate VIII, figure 9), occurring in North America; Water-prince (*Epicordulia princeps* Hagen. Plate VIII, figure 11), also occurring in North America.

True Damsel-fly Family (*Agrionidae*). This family includes about 75 species in our fauna. The females deposit their eggs in the tissue of aquatic plants by cutting slits in the stems with their sharp ovipositors, or in the rubbish and mud along the border of ditches and the fringes of streams.

The males of some species are famous for the duels they fight. Flying about one another,



Photograph by Paul Griswold Howes

A ROBBER FLY WITH ITS PREY, A SCORPION-FLY

It is estimated that about 50 per cent of all the species of insects are engaged in preying on other species of their own kind. The robber flies are all swift, hairy, ferocious-looking creatures, without exception predatory. Some of them are very large, as much as two inches long. These latter do not hesitate to attack dragon-flies and bumble-bees and even the fierce and active tiger-beetles.

evidently in a consuming rage, each tries to get into a position to tear the other's wings, and the duel usually ends only when one of the contestants has been vanquished.

The Ruby-spot has been called by Kellogg a perfect masterpiece of insect beauty and grace. Only the males possess the colorful gems in their wings that give the species its name. Sometimes hundreds of them cling to willow branches in graceful festoons, where they look like strings of rubies.

The species reproduced are: Philippine Damsel-fly (*Pseudophaea refulgens* Selys. Plate VIII, figure 1), occurring in the Philippine Islands; Black-wing Damsel-fly (*Agrion maculatum* Beauv. Plate VIII, figure 2), inhabiting the eastern part of the United States; *Vestalis melania* Selys. (Plate VIII, figure 3), inhabiting the Philippines; Ruby-spot (*Hetaerina americana* Fab. Plate VIII, figure 7), habitat North America; *Neurobasis chinensis* Linn. (Plate VIII, figure 10), occurring in the Philippines.

BEES, WASPS, ANTS, AND THEIR KIN

(Order *Hymenoptera*)

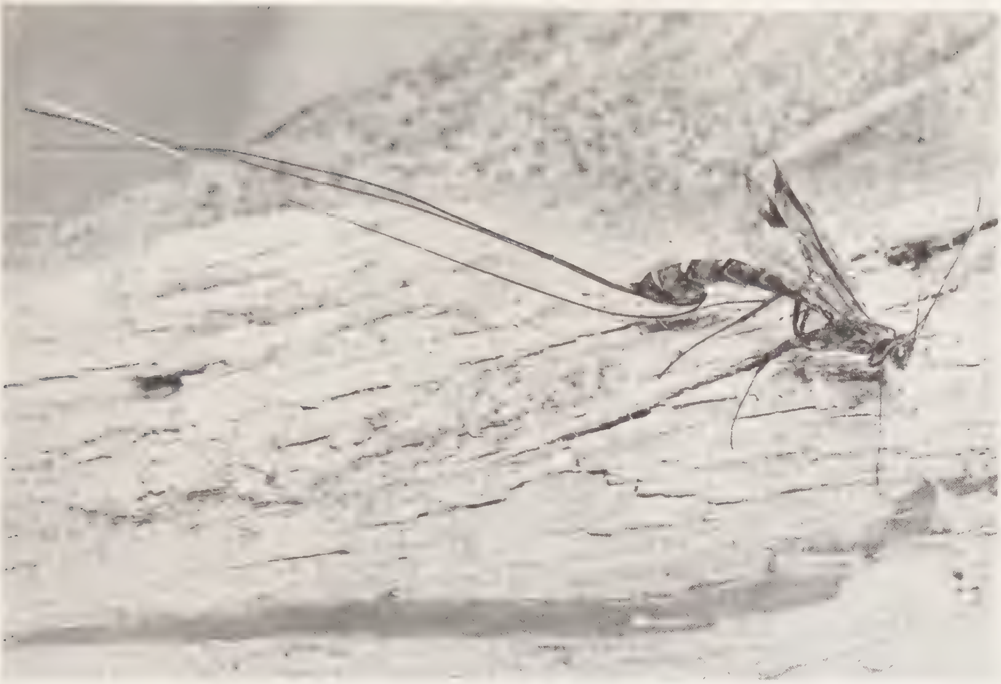
Plates X, XI, XII, XIII

More than 30,000 known species are grouped in this order, and there are perhaps ten times as many that never have been described, embracing not only the bees, wasps, and ants, but also the saw-flies, horn-tails, ensign flies, chalcid flies, gall flies, ichneumon flies, cuckoo flies, and many other lesser suborders, superfamilies, and families.

Thread-waisted Wasp Family (*Sphecidae*). Many species of solitary and hunting wasps, ranging in size and character of prey from the giant Cicada-killer to the little crabros whose quarry consists of harmless flies, are included in this family. They bag their game with rare finesse and preserve it with consummate art.

The familiar mud-daubers that build their several tubular cells side by side beneath porch roofs, on ceilings, and under the eaves of houses are characteristic members of the family. Although they work in mud, the mud-daubers are exquisite in their habits. If we watch one of them gathering a pellet of mud we will see her feet get dirty and the ends of her mandibles soiled; but, figuratively, she has her skirts carefully tucked up and her sleeves as carefully rolled out of harm's way. And when her work is over every particle of dirt must be scraped off both mandibles and feet.

When the dog days are with us, and lyremen, harvest-flies, and dog day cicadas begin their



Photograph by Lynwood M. Chace

AN INSECTEAN DRILL—(THALESSA) MEGARHYSSA LUNATOR

This ichneumon fly preys on the larvæ of the pigeon tremex, one of the horn-tails. The lowest of the three threadlike appendages is a flexible ovipositor. When the female finds the gallery of a pigeon tremex larva she elevates the ovipositor in a loop over her back and brings the tip down to the surface of the wood. She then makes a derrick out of her body and proceeds with great skill and precision to drill a hole into the burrow of the tremex. There she deposits an egg, from which soon emerges a larva to attack the larva of the tremex (see, also, text, page 52).

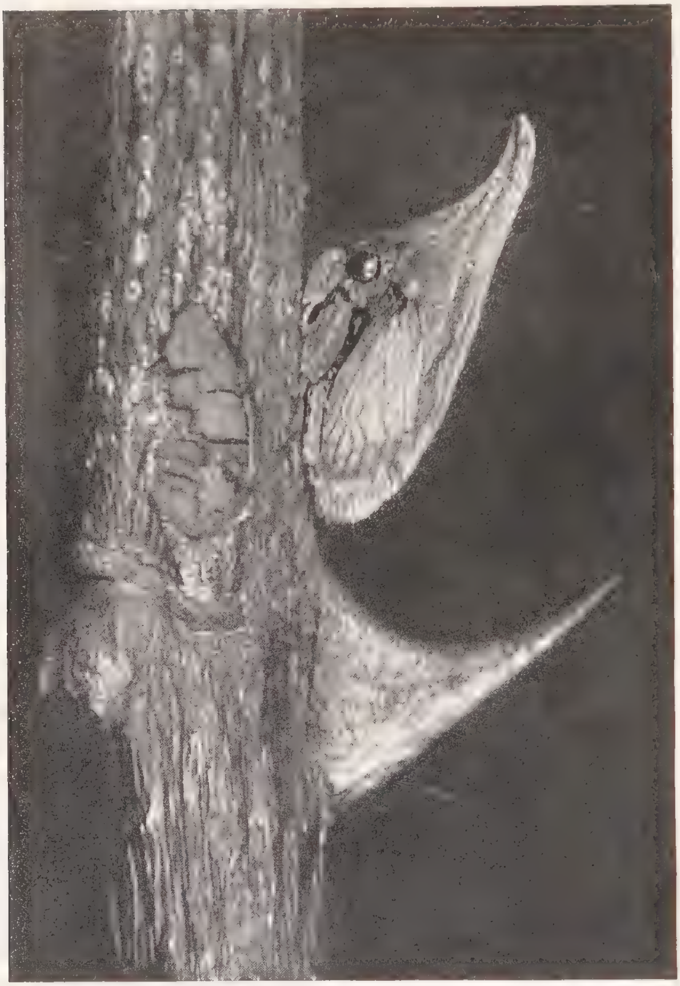
yearly din, their big, yellow-banded, rusty-black wasp enemy makes her appearance upon the scene, having come up out of the big burrow in clayey soil where her mother cradled her. Watch carefully and you will see the big huntress flying around in the vicinity of the source of the cicada's song. Suddenly that song ceases, and in its stead there comes a shrill, distressing, discordant note. The big wasp has driven her venomed dagger into the songster's nerve center, and with a shriek of pain the latter tumbles, along with its conqueror, to the ground.

Then comes the huntress's task of carrying her prey to her burrow. It is heavier than she is, so she gets astride it and laboriously drags it up a tree. From that vantage point she volplanes toward her burrow, after the fashion of a flying squirrel, and repeats the process until her home is reached.

Once there, she lays an egg under the middle leg of the victim, seals the cicada in a cell, and starts looking for another quarry. The egg hatches in two or three days, and the grub is assured of juicy meat, for the cicada has been paralyzed and not killed, and keeps fresh as long as the wasp's baby needs fresh meat. The grub attains full growth inside of ten days, and then spends two days spinning a cocoon of mixed silk and earth. In that it spends the winter, emerging from its transformation sleep in time to lend ear to the lyreman's call of a new season.

Another interesting species of this family is the sand wasp, known as the Ammophila. Dr. S. W. Williston, in studying them, discovered that these wasps actually have learned to use tools, but the discovery was so astounding to him that he feared to publish his observations at first, lest all mankind should pronounce him a "Nature faker." But many another entomologist has confirmed his discovery. After a mother Ammophila has finished digging her gallery, she captures a lot of small caterpillars or other insects, according to her species, paralyzes them, stocks the cell with them, and, after laying an egg in proximity to the provender, seals up the nest; then she fills the burrow with dirt. She often has been observed using a small pebble as a "tamping iron" to pack the soil in solidly, so as to remove effectually all trace of the gallery.

The Cerceris wasps, of which there are numerous American species, also belong to this family. They are exploiters of beetles and weevils. Some species specialize on the adults



Photograph by L. G. Saunders

A "BROWNIE" THAT MIMICS A THORN

One needs only to glance at the thorn itself and the tree-hopper above it to see how difficult it would be for an enemy of this insect to distinguish it from the thorn, whose protection it seeks through imitation (see, also, illustration, page 43).

of the flat-headed wood-borers. But though these vary widely alike in size, color, and aspect, the wasps that hunt them are able to recognize all of them with as much accuracy as the entomologist. Defour found 400 beetles that represented all the hues of the tar pot and the lapidary's show case combined, and were of all shapes and sizes, in Cerceris wasp cells. The wasps that gathered them never once went out of the wood-borer clan for their prey. Those Cerceris wasps that hunt weevils are just as good classificationists as the hunters of flat-headed wood-borers. Little weevils, big weevils, highly colored weevils, and those that are garbed in drab hues are all recognized by their wasp exploiters.

Anatomists who are masters of their art are the members of this family. Whether they be species that hunt wood-borers or species that prey upon weevils, each captive has its nerves centered in one ganglion. One thrust from the wasp's poisoned dagger produces complete paralysis, but not death, for death would mean mortification in a few days, and the babies of Cerceris must have fresh meat.

For weeks the beetle lives on, under the most powerful of sense-extinguishers. The wasp's egg, laid at the tenderest spot of the beetle's abdomen, hatches out, and the little grub begins to eat its way into the interior of the victim's carcass. But though the beetle's meat is as fresh as the day it was stung, there is no movement and no sense of pain.

Such a skilled surgeon was the mother of the grub that with her lance and her drug she was able to arrest sense and motion, and yet leave life. It is as if a man were to thrust a dagger into a steer's neck, insert with a hypodermic syringe a bit of poison into the wound, and establish a paralysis that would enable his child to carve the victim piecemeal over a period of four or five weeks, the beef meanwhile retaining its original freshness.

Another of the thread-waisted wasp family is Philanthus, a hunter of bees, not for her own rations but for her babies. For in her adult life she is a honey drinker and nectar sipper, while her babies are meat eaters. To present them with bees whose honey sacs were filled would be like giving a child a bouquet with a viper hidden in the flowers. Yet Mrs. Philanthus scarcely would be able to single out bees with empty crops. She therefore is under the necessity of emptying the bees' honey sacs before presenting them to her grubs. To do this she cannot deal with paralyzed bees.

Only death itself will produce that muscular relaxation necessary to force the last drop out of the bee's crop. Therefore, we find in her a new kind of surgeon. She has discovered that by forcing down the head of the bee, a tiny opening in its armor is found—an opening less than one twenty-fifth of an inch in diameter. With unerring aim Mrs. Philanthus causes her sting to penetrate the vital spot. A little poison is injected into the wound, and almost instantly antennæ and mandibles become still. Death supervenes in a minute or so, and then the wasp begins a kneading process that forces out the last drop of honey from the bee's crop. This she drinks with gusto, and then carries the honey-drained victim to her home and gives it to her baby.

The species reproduced are: Sphex Wasp (*Chlorion cyaneum* Dahlb. Plate X, figure 1), inhabiting North America; Siamese Wasp (*Chlorion lobatum* Fab. Plate X, figure 3), native of Siam; Cicada-killer Wasp (*Sphecius speciosus* Drury. Plate X, figure 10), inhabiting the United States; Solitary Wasp (*Stictia signata* Linn. Plate XI, figure 2), occurring in Central America; American Mud-dauber (*Sceliphron caementarium* Drury. Plate XI, figure 7), living in North America; American Hunting Wasp (*Ammobia ichneumonea* Linn. Plate XI, figure 9), occurring in North and Central America.

Velvet Ant Family (*Mutillidae*). These handsome insects are not ants at all, but rather wingless wasps, which so closely resemble ants as frequently to be confused with them. Only the females are wingless, the males being possessors of the art of flight. Most of the members of this family are guests or parasites in the nests of other wasps and bees. They are strong stingers and swift runners, and number about 200 species in the United States.

The species reproduced is: Velvet Ant (*Dasymutilla occidentalis* Linn. Plate X, figures 2 and 6), found in North America.

Spider Wasp Family (*Psammocharidae*). Most species of this family are digger wasps, although a few are masons. The giant tarantula killer, the largest of all our wasps, belongs to this clan, and its sensational combats with the great hairy tarantula often are seen in the Southwest. Occasionally both lose, the tarantula paralyzed by the wasp's sting and the wasp dying from the poisonous wounds made by the great fangs of the spider. Those wasps of the family which burrow in the ground first find their victims and sting them until they are paralyzed. Then they dig a burrow, which is enlarged at the lower end, forming a cell for the reception of the spider; and the quarry then is dragged down into the cell and an egg attached to it, after which the passage to the cell is filled with earth.

The species reproduced is: Spider Wasp (*Pepsis cinnabarina* Lucas. Plate X, figure 4), which occurs in the southern part of North America and Central America.

Carpenter-bee Family (*Xylocopidae*). The carpenter-bees build their nests in wood. Perhaps the most familiar member of this family

Photograph by Paul Henri Fabre

STAG-BEETLES READY TO DO BATTLE OVER A FEMALE OF THE SPECIES

The adult beetles are found on trees, where presumably they live, for the most part, on the sap flowing from bruised places, and on honeydew of aphids and scale insects. Their eggs are laid in crevices of the bark near the base of the trunk. The fat-bodied grubs burrow into the tree, where they stay, in some species, for as long as six years.

Photograph by Lynwood M. Chace

A CRICKET'S GOLDEN CASTLE—A PUMPKIN BLOSSOM

"April comes to an end, and the cricket's song begins, at first in rare and shy solos, soon developing into a general symphony, in which every clod of turf boasts its performer." (See, also, text, page 37).

is the big, black carpenter-bee, as large as a bumble-bee, which excavates a burrow one-half inch in diameter in dry lumber. This burrow runs across the grain for about half an inch, and then makes a right-angle turn and runs with the grain for from 12 to 20 inches.

The bee works from two to three days on the small section of the tunnel that runs across the grain, and from three to five weeks on the remainder. If man did as much in proportion to his size, he could dig a tunnel two feet in diameter from end to end of a log 90 feet long, with no tool but his teeth.

The species reproduced are: Sumatran Carpenter-bee (*Xylocopa caerulea* Fab. Plate X, figure 5), inhabiting Sumatra; American Carpenter-bee (*Xylocopa virginica* Linn. Plate XI, figure 1), occurring in North America; Carpenter-bee (*Xylocopa bombylans* Fab. Plate XII, figure 8), living in Australia.

Euglossid Bee Family (*Euglossidae*). The several species of this family of bees are solitary in habits. Many of them have not been studied carefully, but those which are known build their nests from bits of boxwood which they fasten together with the resin or gum of trees.

The species reproduced are: Tropical Bee (*Eulaema dimidiata* Linn. Plate X, figure 7), a native of Central America; South American Bee (*Exaerte frontalis* Guer. Plate X, figure 8), found in Central and South America; *Euglossa variabilis* Friese. Plate XII, figure 10), found in Central America.

Social Wasp Family (*Vespidae*). This family includes the hornets, the yellow-jackets, and the wasps that build paper nests. Unlike the social bees and ants, the members of the social wasp family found in temperate regions

Photograph by Lynwood M. Chace

A CRICKET CONFERENCE ON AN EAR OF CORN

While the crickets we know best are the black and brown varieties found in houses and fields, there are many others we see less frequently. Some of these live in trees like katydids, others burrow into the ground like moles, and still others dwell as guests in ants' nests. Most of them hear with their legs and sing with their wings (see text, page 14).

are unable to set up a permanent communal life.

There is a vast lot of work to be done in the making of a hornet's nest as big as a half bushel. In the spring it is smaller than a hen's egg; it has been built by some queen that has survived the winter. The house must be made roomier as the family grows, not by building additions here and there, but rather by a gradual and symmetrical expansion of the entire structure. Think how often each bit of weatherboarding must be moved to keep the size of the house always expanding uniformly with the increase in the size of the family!

But the hornets are equal to the task, though that task is as if we took a six-room house and expanded it into a Windsor Castle without interfering in the slightest with the family routine on the inside, or with the shapeliness of the structure on the outside.

The hornets have the requisite engineering skill to carry the undertaking through to a successful conclusion. They gather from the weathered surfaces of boards, rails, and posts the pulp out of which they build the walls of the nest. Bit by bit they take the material from the inside of the nest walls and plaster it on the outside, supplementing it with new material gathered abroad. In this way the inside of the house always is being put on the outside, and the growth of the nest provided for.

Many species of yellow-jackets build their nests in hollow logs and stumps. What most laymen know as the common wasp belongs to the genus *Polistes* of the *Vespidae* family. It builds but a single comb, always in a place protected from the elements, so that there is no need for the outer covering provided by the hornets. Like their cousins, the yellow-jackets and the hornets, they bring food to their babies as it is needed rather than store it up in the cell before the egg is deposited. There are some exceptions to the general rule that the *Vespidae* are social wasps. A few unfamiliar species are solitary in their habits.

The species reproduced are: Asian Wasp (*Vespa mandarina* Smith. Plate X, figure 9), found in Asia; European Social Wasp (*Vespa crabro* Linn. Plate XI, figure 10), a native of Europe and Asia and introduced into North America; Yellow-jacket (*Vespula carolina* Linn. Plate XII, figure 6), found in North America.

Bumble-bee Family (*Bombidae*). The bumble-bee family is represented by numerous species in our fauna, most of whose communities are short-lived rather than permanent. The only individuals that live over winter are the fertilized females. They find some cranny or crevice where the frost cannot reach them, and there fall into a winter-long sleep.

When spring arrives they seek a deserted mouse hole, mole burrow, or other cavity in the ground. To these nests they bring pollen and honey which they knead into bread. Then they lay eggs in simple cells, and the larvæ that hatch from them grow fat and strong on the bread prepared in advance by the mothers. When the grubs are grown they spin silken cocoons in which they pupate, and out of which they emerge full-fledged bumble-bees. Then they immediately set to work looking after the welfare of their newly hatched younger sisters and brothers, serving as nursemaids, housemaids, food gatherers and what not, and freeing their elder sisters for field work.

When winter approaches the colony dies, leaving behind only a few fertilized females, whose duty it will be to start the work again the next year. There are some species of bumble-bees that are parasitic on their more industrious cousins. They closely resemble the working clans and possess no worker caste.

The species reproduced is: Common Bumble-bee (*Bombus americanorum* Fab. Plate XI, figure 3), found in North America.

Ichneumon Fly Family (*Ichneumonidae*). The ichneumon fly family possesses some 6,000 known species. Most of them are parasitic and exploit the caterpillar tribe, thus helping to keep in check some of the worst enemies of the American garden, orchard, truck patch, and field. The adults, as a rule, lay their eggs on the caterpillars, and the larvæ hatch out and burrow into the wretched host, literally eating it alive. Anyone who gathers cocoons to see what kinds of insects issue therefrom will have ichneumon flies coming from them almost as frequently as the rightful owners.

An interesting ichneumon is known as (*Pimpla*) *Ichneumon conquisitor*. It preys on the tent-caterpillar. When the latter's cocoon is spun, the ichneumon, with its ovipositor, makes an opening in the silken case and deposits its egg. The parasite has at once a choice cradle and a meal for its needs—at the expense of the sleeping, transforming caterpillar.

Another species, (*Pimpla*) *Ichneumon inquisitor*, preys not only on tent-caterpillars but also on army-worms, tussock moths, caterpillars, and the like.

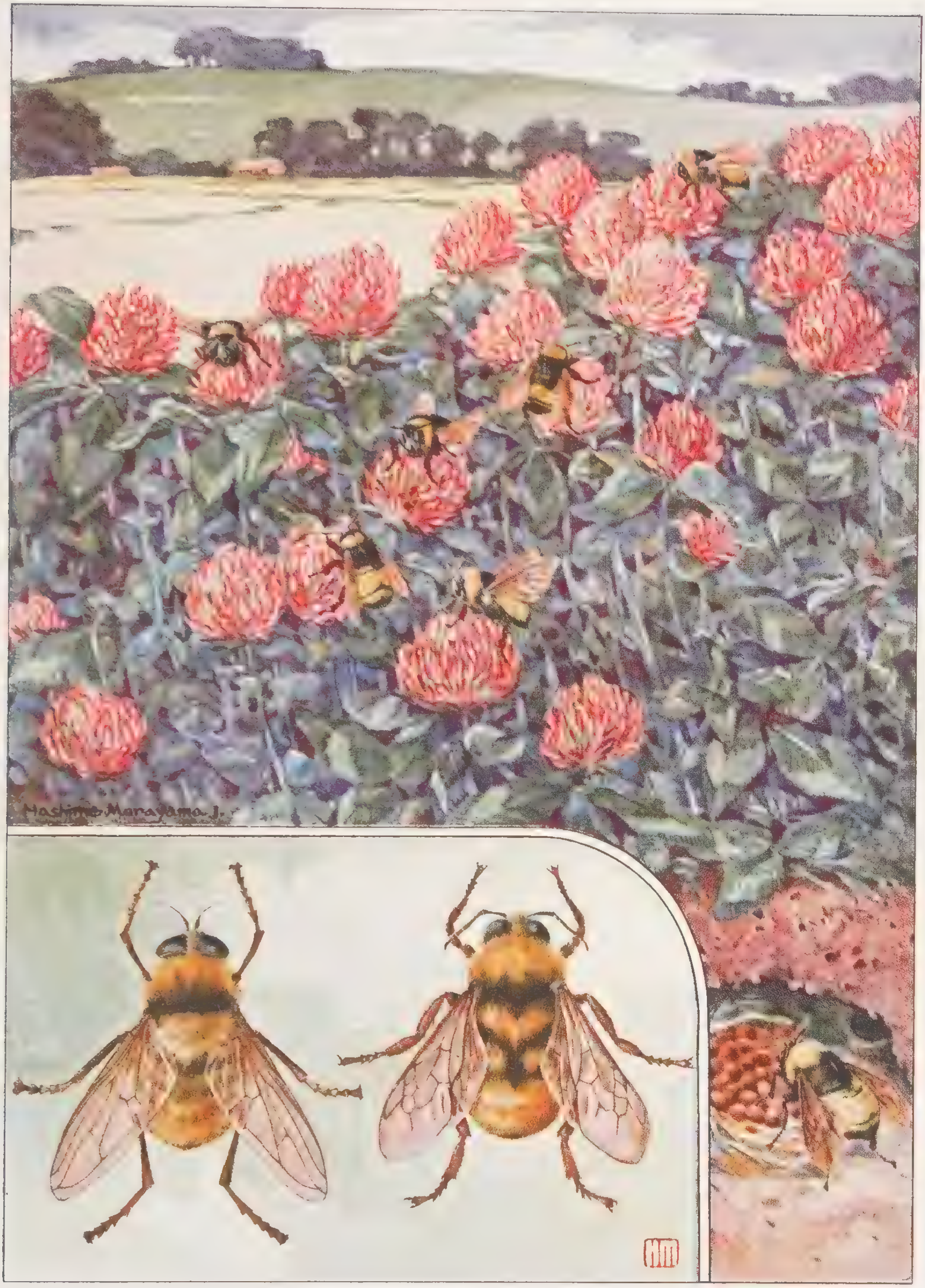
The most interesting of all the ichneumon flies is probably (*Thalessa*) *Megarhyssa lunator*. The female of this species has an amazing ovipositor, often as long as six inches, which is made up of several hairs and a flexible tube. The hairs form a sheath for the latter, which is the boring-tool proper. Thin and flexible as it seems to be, Mrs. Thalessa, once she has located, deep in the hard wood of a tree, the boring grub of a pigeon tremex, bends her long abdomen down, throws her ovipositor up over her back and brings the end of it down to the wood. She then begins as fine a drilling operation as one would wish to see, often driving the hole down three or four inches into the wood (see illustration, page 47). After the female completes the boring, she converts her drill into an egg-tube, and through it pumps an egg down into the burrow of the pigeon tremex's baby (see, also, Horn-tail Family, page 61).

This egg promptly hatches, and soon attaches itself to the luckless tremex grub which it gradually devours, and then lies down for a transformation nap.

Sometimes when Mrs. Thalessa starts to drill, the wood is so tough that it grips her drill and she remains a prisoner until starvation ends her career.

The species reproduced are: American Ichneumon Fly (*Amblyteles grandis* Brulle. Plate XI, figure 4), American Ichneumon Fly (*Trogus elegans* Cress. Plate XI, figure 5), American Ichneumon Fly (*Trogus rileyi* Cress. Plate XI, figure 6), *Agathilla bradleyi* Vireck (Plate XIII, figure 1), *Amblyteles jucundus* Brulle. (Plate XIII, figure 4), *Platylabus clarus* Cress. (Plate XIII, figure 5), *Amblyteles jucundus* Brulle. (Plate XIII, figure 6), *Polyaenus spinarius* Brulle. (Plate XIII, figure 8), *Amblyteles w-album* Cress. (Plate XIII, figure 9), *Ichneumon irritator* Fab. (Plate XIII, figure 10), *Amblyteles semicaeruleus* Cress. (Plate XIII, figure 11), *Labena grallator* Say. (Plate XIII, figure 12), all found in North America; *Macrojoppa blandita* Cress. (Plate XIII, figure 2), habitat Central America; *Cyanoxorides caeruleus* Cameron. (Plate XIII, figure 3), found in the Philippine Islands; *Callicryptus fasciipennis* Brulle. (Plate XIII, figure 7), a species found in Cuba; *Lissopimpla semipunctata* Kirby. (Plate XIII, figure 13), native of Australia.

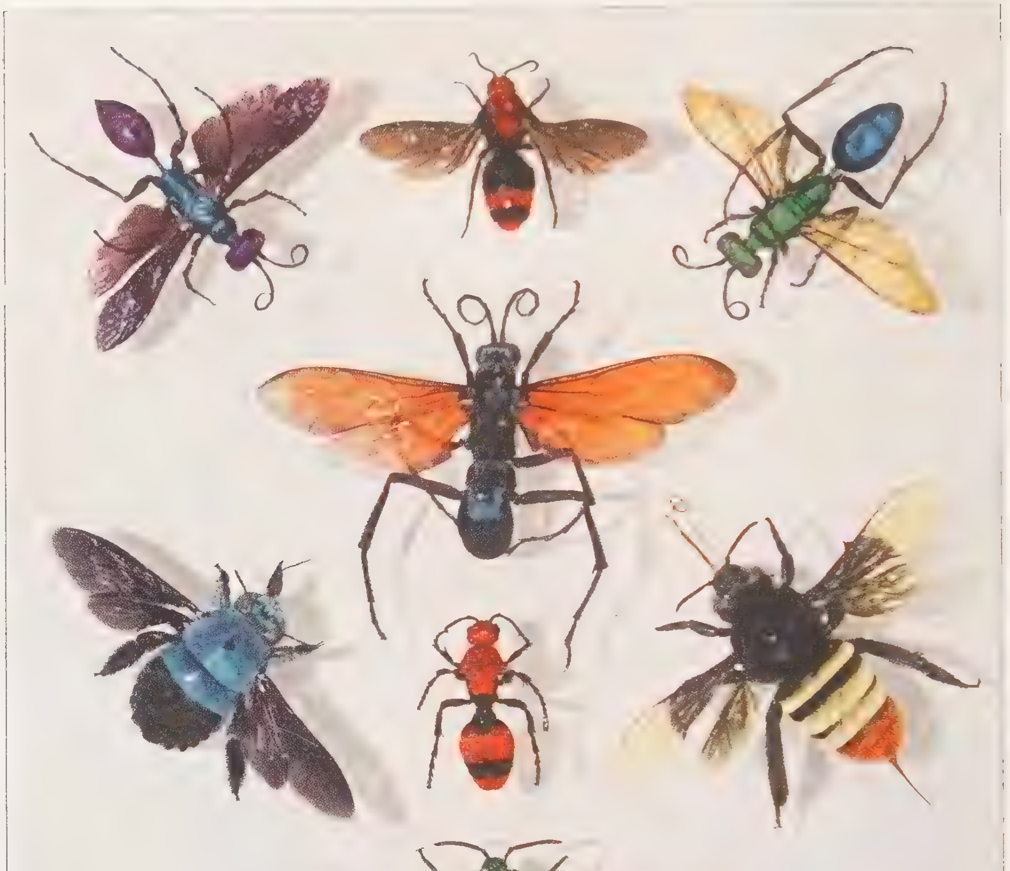
Scoliid Wasp Family (*Scoliidae*). The species of this family neither builds nests nor transports prey to them. Rather it digs into the ground, where the grubs of the family to which the May beetle belongs are to be found. Discovering one of these, the wasp stings and



© National Geographic Society Painting by Hashime Murayama

THE BUMBLE-BEES GATHERING NECTAR IN THE CLOVER FIELD

The artist here has succeeded in giving a typical picture story of the life of the Bumble-bee Family. In the inset the figure on the right is the familiar bumble-bee of the East, and that at the left a fly that has copied it in appearance so thoroughly that the bumble-bees receive it as a welcome guest in their nests. The species portrayed in the main picture is *Bombus americanorum;* the one in the inset is *Bombus huntii.* The fly belongs to the species *Criorhina kincaidi.* The fly and bumble-bee in the inset are 1½ times natural size.



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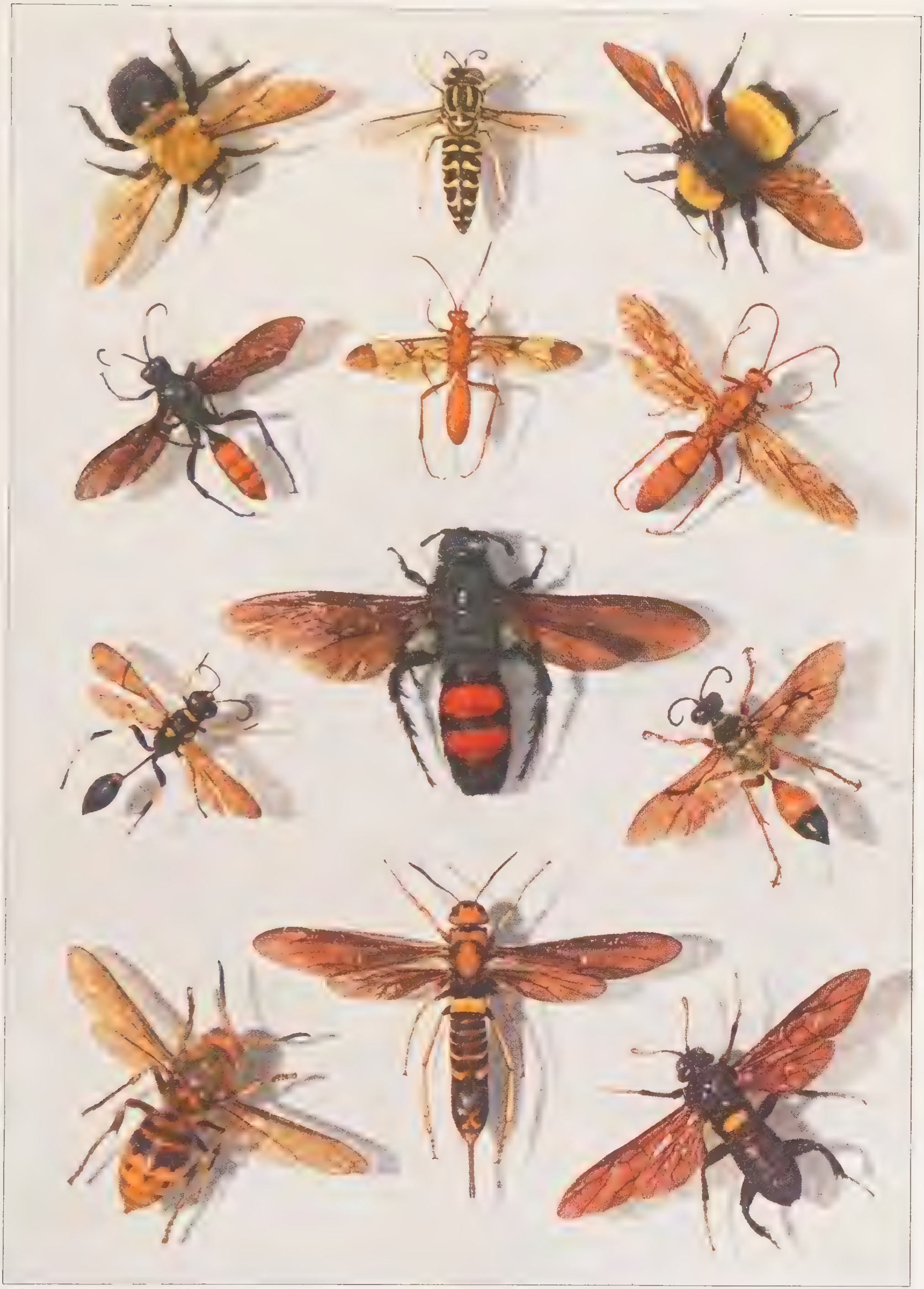
Natural Size

SOME OF THE FAIREST AMONG THE WASPS, BEES, AND VELVET ANTS

(1) Sphex Wasp, *Chlorion cyaneum* Dahlb. [Female]; (2) Velvet Ant, *Dasymutilla occidentalis* Linn. [Male]; (3) Siamese Wasp, *Chlorion lobatum* Fab. [Female]; (4) Spider Wasp, *Pepsis cinnabarina* Lucas [Female]; (5) Sumatran Carpenter-bee, *Xylocopa caerulea* Fab. [Female]; (6) Velvet Ant, *Dasymutilla occidentalis* Linn. [Female]; (7) Tropical Bee, *Eulaema dimidiata* Linn. [Female]; (8) South American Bee, *Exaerte frontalis* Guer. [Female]; (9) Asian Wasp, *Vespa mandarina* Smith [Female, queen]; (10) Cicada-killer Wasp, *Sphecius speciosus* Drury [Female]. See text under the following Family headings: Thread-waisted Wasp, Velvet Ant, Spider Wasp, Carpenter-bee, Euglossid Bee, and Social Wasp. The habits of the several species of these insects show to what a high degree of versatility members of a single Order may attain, whether in social relationships, home-building habits or food-gathering and storing methods.



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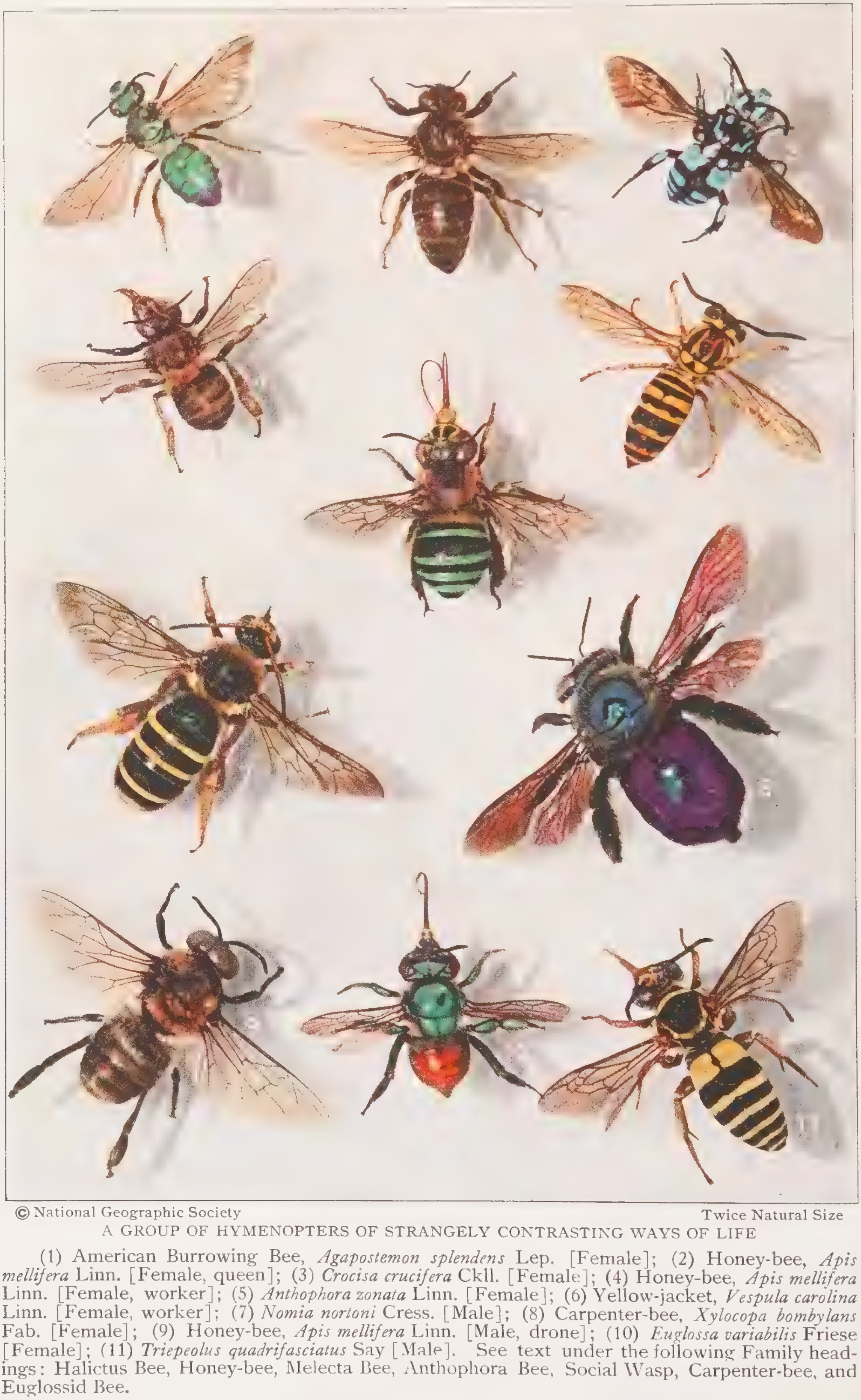
1⅛ times Natural Size

FROM CARPENTER-BEES TO SAW-FLIES RANGES THE COLLECTION ON THIS PLATE

(1) American Carpenter-bee, *Xylocopa virginica* Linn. [Male]; (2) Solitary Wasp, *Stictia signata* Linn. [Female]; (3) Common Bumble-bee, *Bombus americanorum* Fab. [Female, queen]; (4) American Ichneumon Fly, *Amblyteles grandis* Brulle [Female]; (5) American Ichneumon Fly, *Trogus elegans* Cress. [Female]; (6) American Ichneumon Fly, *Trogus rileyi* Cress. [Female]; (7) American Mud-dauber, *Sceliphron caementarium* Drury [Female]; (8) South American Burrowing Wasp, *Campsomeris ephippium* Say [Female]; (9) American Hunting Wasp, *Ammobia ichneumonea* Linn. [Female]; (10) European Social Wasp, *Vespa crabro* Linn. [Female]; (11) Common Horn-tail, *Tremex columba* Linn. [Female]; (12) American Saw-fly, *Cimbex americana* Leach [Male]. See text under the following Family headings: Carpenter-bee, Thread-waisted Wasp, Bumble-bee, Ichneumon Fly, Scoliid Wasp, Horn-tail, and Cimbicid.



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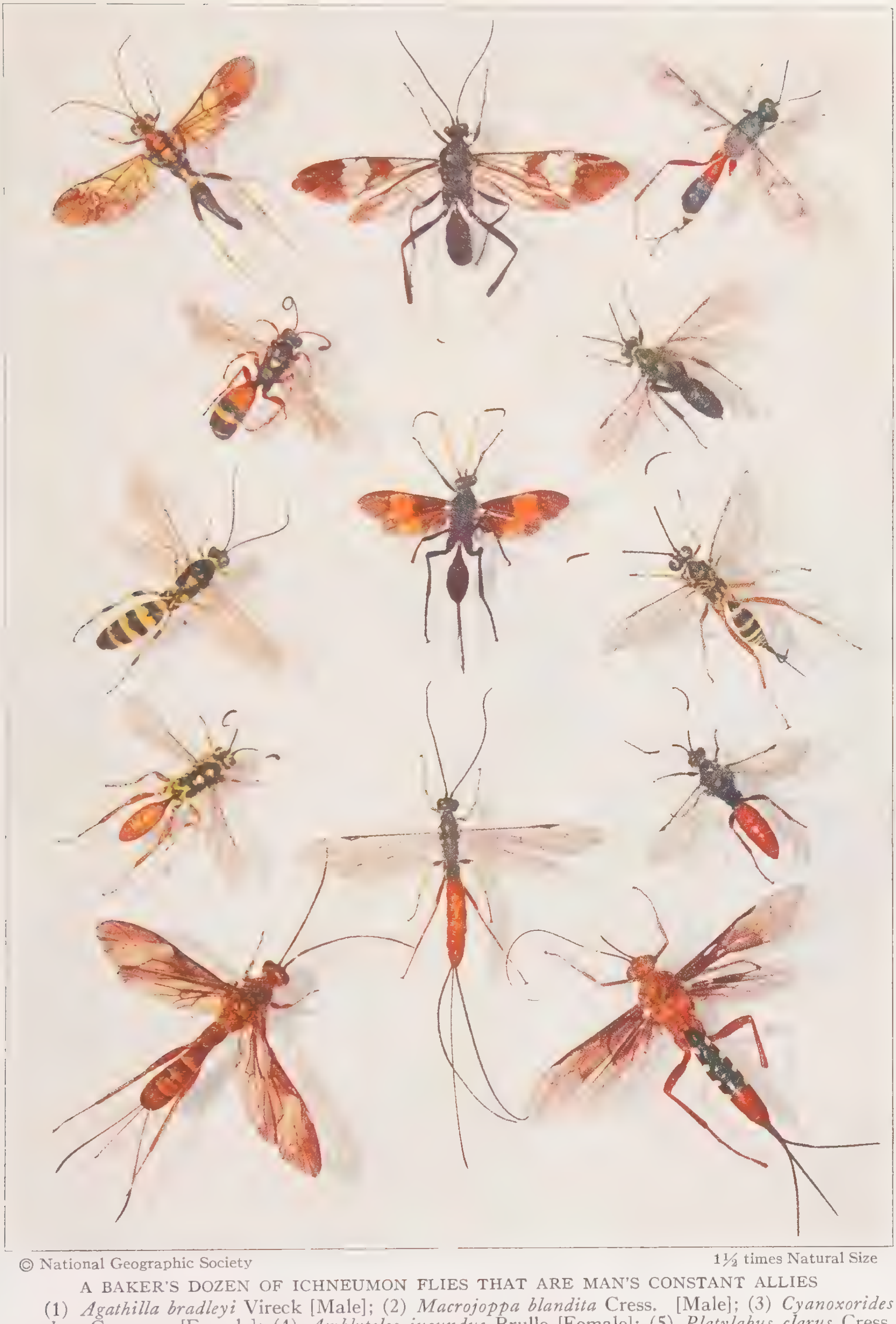
Twice Natural Size

A GROUP OF HYMENOPTERS OF STRANGELY CONTRASTING WAYS OF LIFE

(1) American Burrowing Bee, *Agapostemon splendens* Lep. [Female]; (2) Honey-bee, *Apis mellifera* Linn. [Female, queen]; (3) *Crocisa crucifera* Ckll. [Female]; (4) Honey-bee, *Apis mellifera* Linn. [Female, worker]; (5) *Anthophora zonata* Linn. [Female]; (6) Yellow-jacket, *Vespula carolina* Linn. [Female, worker]; (7) *Nomia nortoni* Cress. [Male]; (8) Carpenter-bee, *Xylocopa bombylans* Fab. [Female]; (9) Honey-bee, *Apis mellifera* Linn. [Male, drone]; (10) *Euglossa variabilis* Friese [Female]; (11) *Triepeolus quadrifasciatus* Say [Male]. See text under the following Family headings: Halictus Bee, Honey-bee, Melecta Bee, Anthophora Bee, Social Wasp, Carpenter-bee, and Euglossid Bee.



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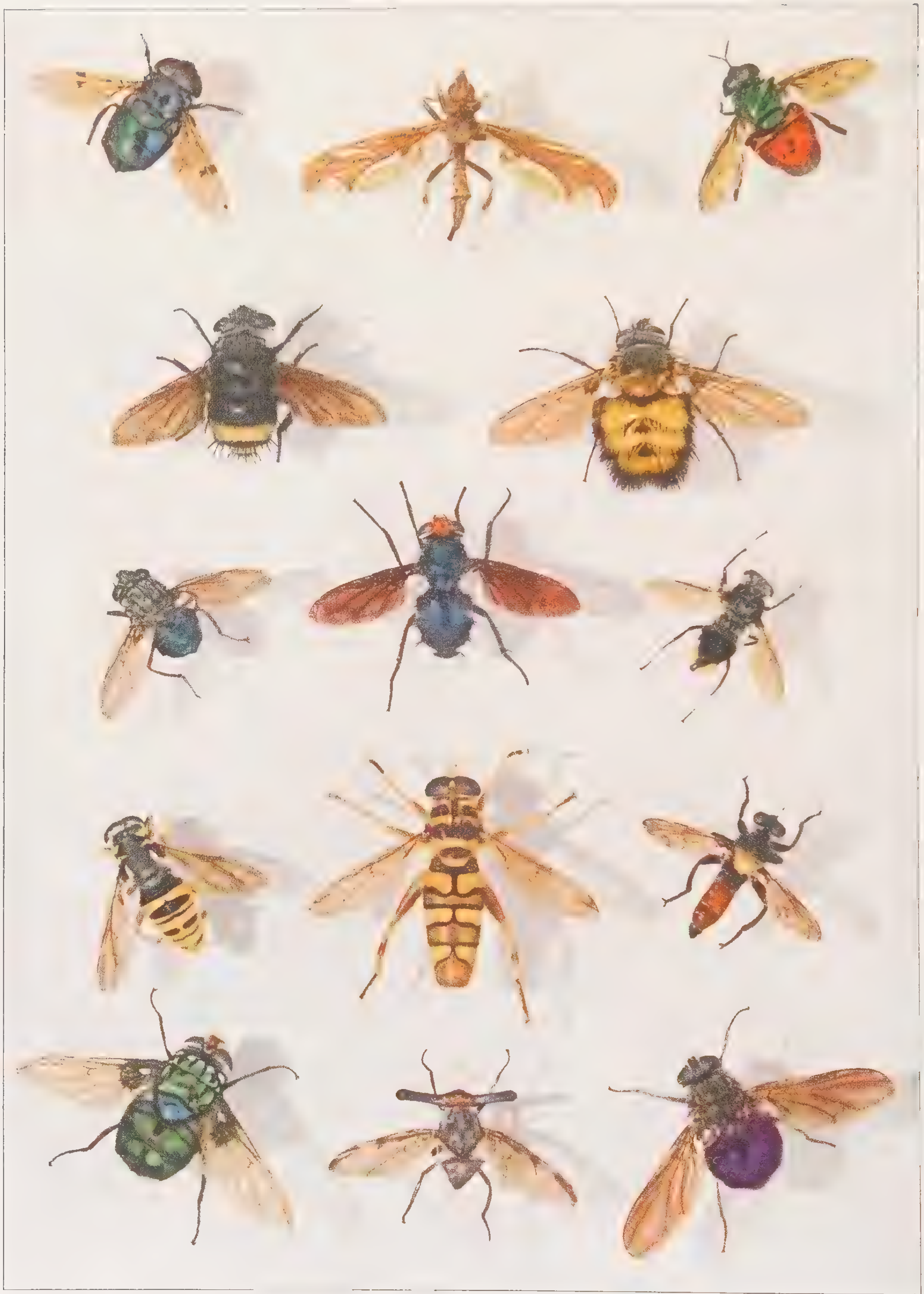
1½ times Natural Size

A BAKER'S DOZEN OF ICHNEUMON FLIES THAT ARE MAN'S CONSTANT ALLIES

(1) *Agathilla bradleyi* Vireck [Male]; (2) *Macrojoppa blandita* Cress. [Male]; (3) *Cyanoxorides caeruleus* Cameron [Female]; (4) *Amblyteles jucundus* Brulle [Female]; (5) *Platylabus clarus* Cress. [Female]; (6) *Amblyteles jucundus* Brulle [Male]; (7) *Callicryptus fasciipennis* Brulle [Female]; (8) *Polyaenus spinarius* Brulle [Female]; (9) *Amblyteles w-album* Cress. [Female]; (10) *Ichneumon irritator* Fab. [Female]; (11) *Amblyteles semicaeruleus* Cress. [Female]; (12) *Labena grallator* Say [Female]; (13) *Lissopimpla semipunctata* Kirby [Female]. All of the species represented on this Plate belong to the single Family of the Ichneumon Flies. Few among any of the Families of all the Orders of insects render man a greater service than the Ichneumon Flies.



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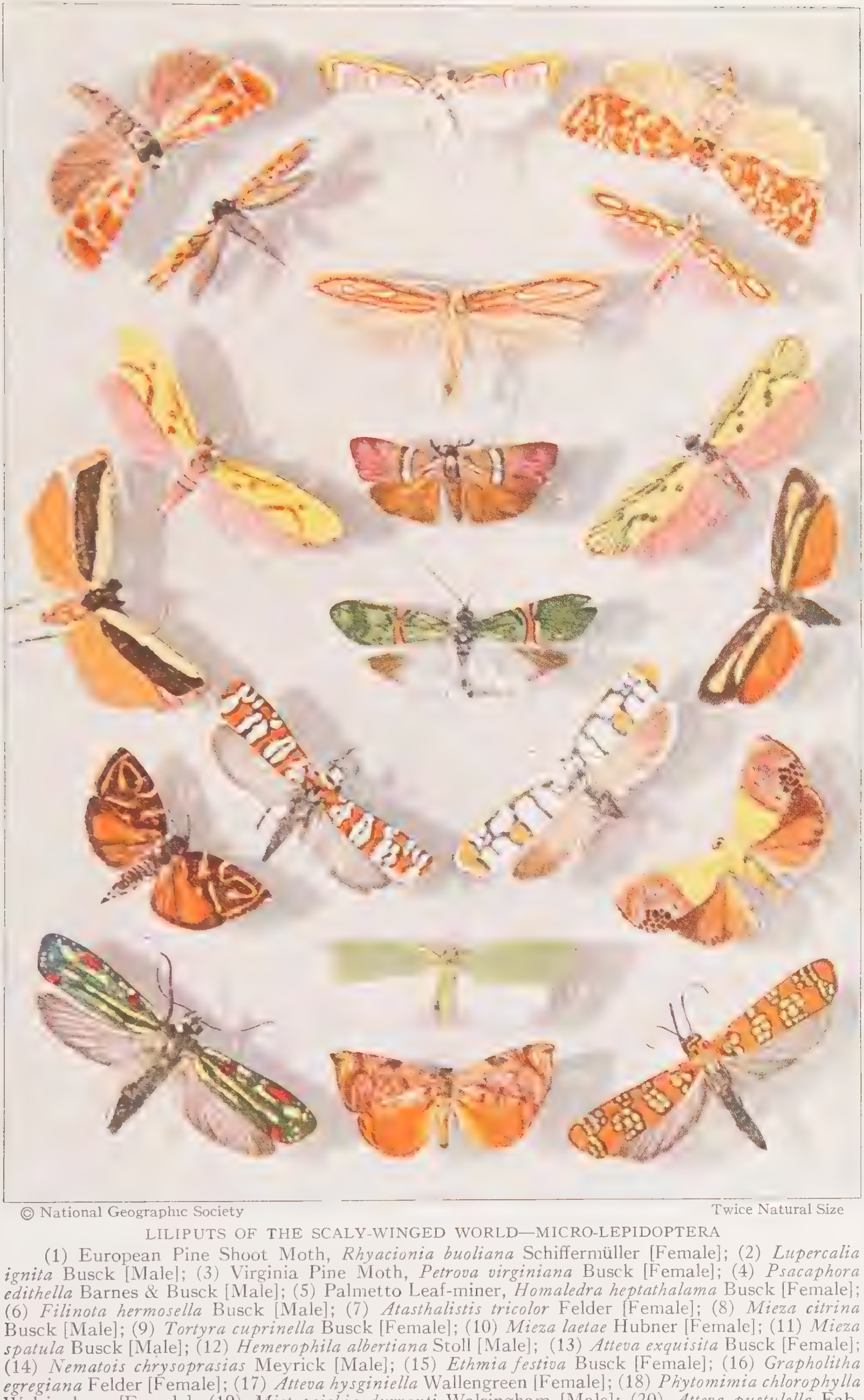
1½ times Natural Size

TWO-WINGED FLIES—FAMILIAR AND OTHERWISE

(1) Tropical Hover Fly, *Volucella obesa* Fab. [Female]; (2) May Beetle Fly, *Pyrgota undata* Wiedemann [Female]; (3) Florida Ant Fly, *Microdon fulgens* Wiedemann [Female]; (4) Eastern Tachina Fly, *Belvesia bifasciata* Fab. [Female]; (5) Western Tachina Fly, *Paradejeania rutiliodes* Jaennicke [Female]; (6) Central American Bot Fly, *Dermatobia hominis* Linn. [Female]; (7) Scavenger Fly, *Silbomyia fuscipennis* Fab. [Female]; (8) Ox Warble, *Hypoderma lineatum* DeVilliers [Female]; (9) Eastern Hover Fly, *Temnostoma excentricum* Harris [Male]; (10) *Milesia virginiensis* Drury [Male]; (11) California Robber Fly, *Laphria coquilletti* McAtee [Male]; (12) Australian Nimble Fly, *Rutilia splendida* Donovan [Female]; (13) *Achias amplividens* Walker [Female]; (14) Costa Rican Blow-fly, *Mesembrinella umbrosa* Aldrich [Female]. See text under the following Family headings: Hover Fly, Pyrgota Fly, Tachina Fly, Bot Fly, Blow-fly, Robber Fly, Nimble Fly, and Ortalid Fly.



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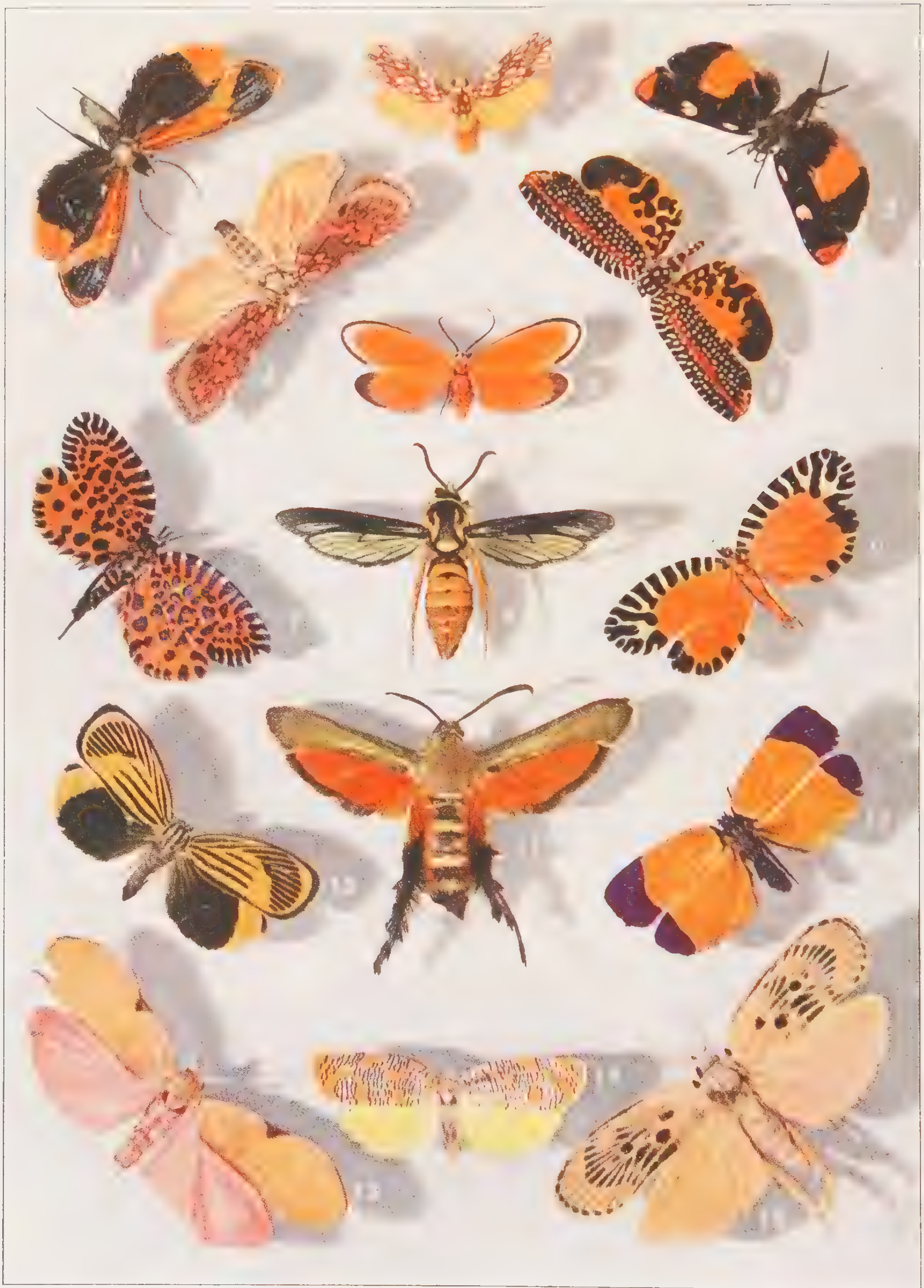
Twice Natural Size

LILIPUTS OF THE SCALY-WINGED WORLD—MICRO-LEPIDOPTERA

(1) European Pine Shoot Moth, *Rhyacionia buoliana* Schiffermüller [Female]; (2) *Lupercalia ignita* Busck [Male]; (3) Virginia Pine Moth, *Petrova virginiana* Busck [Female]; (4) *Psacaphora edithella* Barnes & Busck [Male]; (5) Palmetto Leaf-miner, *Homaledra heptathalama* Busck [Female]; (6) *Filinota hermosella* Busck [Male]; (7) *Atasthalistis tricolor* Felder [Female]; (8) *Mieza citrina* Busck [Male]; (9) *Tortyra cuprinella* Busck [Female]; (10) *Mieza laetae* Hubner [Female]; (11) *Mieza spatula* Busck [Male]; (12) *Hemerophila albertiana* Stoll [Male]; (13) *Atteva exquisita* Busck [Female]; (14) *Nematois chrysoprasias* Meyrick [Male]; (15) *Ethmia festiva* Busck [Female]; (16) *Grapholitha egregiana* Felder [Female]; (17) *Atteva hysginiella* Wallengreen [Female]; (18) *Phytomimia chlorophylla* Walsingham [Female]; (19) *Mictopsichia durranti* Walsingham [Male]; (20) *Atteva pustulella* Fab. [Male]. All of the Families represented on this Plate will be found in the text under the Order heading The Little Moths.



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1⅓ times Natural Size

A CHARMING GROUP OF MICRO-LEPIDOPTERA ARRAYED IN RESPLENDENT ROBES

(1) *Coryptilum klugii* Zeller [Male]; (2) *Lactura conflagrans* Walker [Male]; (3) *Atasthalistis concinnalis* Feisthamel [Male]; (4) *Hypercallia miniata* Dognin [Female]; (5) *Pseudotalara regia* Schaus [Female]; (6) *Cerace onustana* Walker [Male]; (7) *Pseudatteria leopardina* Butler [Female]; (8) *Paranthrene palmi* Harry Edwards [Female]; (9) *Pseudatteria mimica* Felder [Female]; (10) *Imma grammozona* Meyrick [Male]; (11) Western Clear Winged Moth, *Melittia gloriosa* Harry Edwards [Male]; (12) *Megalodoris electrina* Meyrick [Male]; (13) *Stenoma elegans* Zeller [Female]; (14) *Tortrix animosana* Busck [Female]; (15) *Stenoma armata* Zeller [Male]. The Micro-lepidoptera Families lack common names. The species represented on this Plate will be found in the text under the Order heading The Little Moths.

paralyzes it and then builds a crude cell around it, after attaching an egg to the grub. The larva of the wasp, hatching out, consumes the grub and then spins a cocoon in which it develops.

The species reproduced is: South American Burrowing Wasp (*Campsomeris ephippium* Say. Plate XI, figure 8), found in South and Central America.

Horn-tail Family (*Siricidae*). This family consists of about 100 species, about one-third found in America. Its members are mostly rather large, brightly marked, and well-built. The adult female has an ovipositor consisting of five pieces, the two outside ones forming a sheath, and two of the others being furnished at the tip with a series of fine, hard, transverse ridges arranged like the teeth of a file. With this she is able to match the work of a gimlet or auger in human hands, and can drill innumerable holes in the solid wood of a tree. In each of these she places an egg.

The best-known of the horn-tails is the pigeon tremex, which is about one and one-half inches long, with a rusty head and thorax, and a black abdomen with yellow bands and spots. The female bores a hole half an inch deep into elms, oaks, sycamores, and maple trees. The larvæ, hatching from the eggs laid therein, burrow into the heart wood where they grow into cylindrical, blunt-ended, whitish grubs, measuring about an inch and a half in length.

When ready to transform into an adult insect, the grub makes a cocoon of silk and chips, and then goes to sleep. On awakening as a full-fledged pigeon tremex it bores out at right angles to the gallery dug by the grub, instinctively knowing that in such direction lies the shortest way to liberty.

The European grain cephus, whose larvæ bore into the stems of wheat and cause the straw to break about harvest time, belongs to the horn-tail tribe. About the time the head of the wheat begins to form, the fly bores a small hole in the straw. When the larva hatches from the inserted egg, it tunnels down the stem, and by wheat-cutting time has passed below the level of the cutter bar. In this way it remains in the stubble, where it makes a silken cocoon and hibernates.

The species reproduced is: Common Horn-tail (*Tremex columba* Linn. Plate XI, figure 11), found all over North America.

Cimbicid Family (*Cimbicidae*). The most familiar species of the group is the American Saw-fly. Its eggs are laid in June in crescent-shaped slits made in leaves. The food plants are elm, birch, linden, and willow. When disturbed the larva spurts a fluid from glands just above the spiracles. When it is full-grown it burrows in the ground, makes an oval, brownish cocoon, and spends the winter there, not changing to a pupa until spring. It emerges in May or June.

The species reproduced is: American Saw-fly (*Cimbex americana* Leach. Plate XI, figure 12), habitat North America.

Halictus Bee Family (*Halictidae*). Some of these bees are larger than a fair-sized wasp and some are smaller than a house-fly. Every halictus carries what has been called a clearly written certificate of her guild. It is a smooth, shiny line, or groove, on the last segment of the abdomen that acts as a guide for the sting. Some species build wonderful cells for their babies.

The burrows in which these are located may be rough, but the cradles must be perfect. Leading from the burrow, the cells are excavated so as to resemble water bottles laid on the side. No human plasterer ever did a finer job than these bees. First there is a coating of clay, its surface roughened like the outside of a thimble. On this is laid a smooth coat, mixed with saliva and carefully troweled with the tongue—a glazing that is exquisite in its perfection, and both damp- and waterproof.

A small fly which the ordinary observer dismisses as nothing but a gnat, makes it her business to lay her eggs in the halictus's cells. Under the microscope she is revealed as a red-eyed, white-faced, gray-corseleted, black-legged marauder.

One species of this family studied by Fabre, the zebra halictus, possesses a quality rarely observed in the insect world—interest in grandchildren. The mother bee, of the spring generation, having passed the winter in some frost-proof retreat, gives the mansion she has built so laboriously to her daughters. Each daughter builds a small addition to the burrow and makes a group of cells of her own, but all use the main burrow in common.

The grandmother of the brood in the cells stands guard at the doorway, to keep out all but the rightful entrants—her daughters. Her velvet dress, so clean and handsome when she was a youthful matron, is now threadbare and dingy. Gone is the nap, all but lost are the beautiful stripes of red and brown.

But she has a grandmother's pride in the newly hatched grubs, and woe betide any creature who cannot show the yellow foot of the halictus folk when seeking to reach those grub chambers! A drubbing the marauder never will forget will be his certain portion. At the door, all day long, sits poor, bald-headed grandmother, a ghost of her former self, in a little sentry box at the mouth of the burrow, stepping aside to all those who can give the countersign, but wild as a witch in her anger toward any would-be intruder. Mayhap her remarkable guard over her grandchildren comes from the knowledge that some of them will be males. Denied the privilege of having sons, by that strange quirk of Nature which makes all the children of the spring generation females, she must look to her grandchildren for her male progeny. And each of those grandchildren is hatched into the world without a father.

With no males produced from the eggs of the spring mother, and no males having survived the winter, they perforce are born under that strange departure from the orthodox laws of reproduction known as parthenogenesis.

Photograph by Maynard Owen Williams

A CHINESE PEDDLER OF BIRD AND CRICKET CAGES

Singing crickets in cages are as familiar in the Orient as singing canaries in the Occident. Even the department stores in the larger cities of Japan cater to the cage-cricket trade. Hundreds of thousands of the insect Kreislers are sold every year.

The species reproduced are: American Burrowing Bee (*Agapostemon splendens* Lep. Plate XII, figure 1), common in North America; *Nomia nortoni* Cress. (Plate XII, figure 7), occurring in North America.

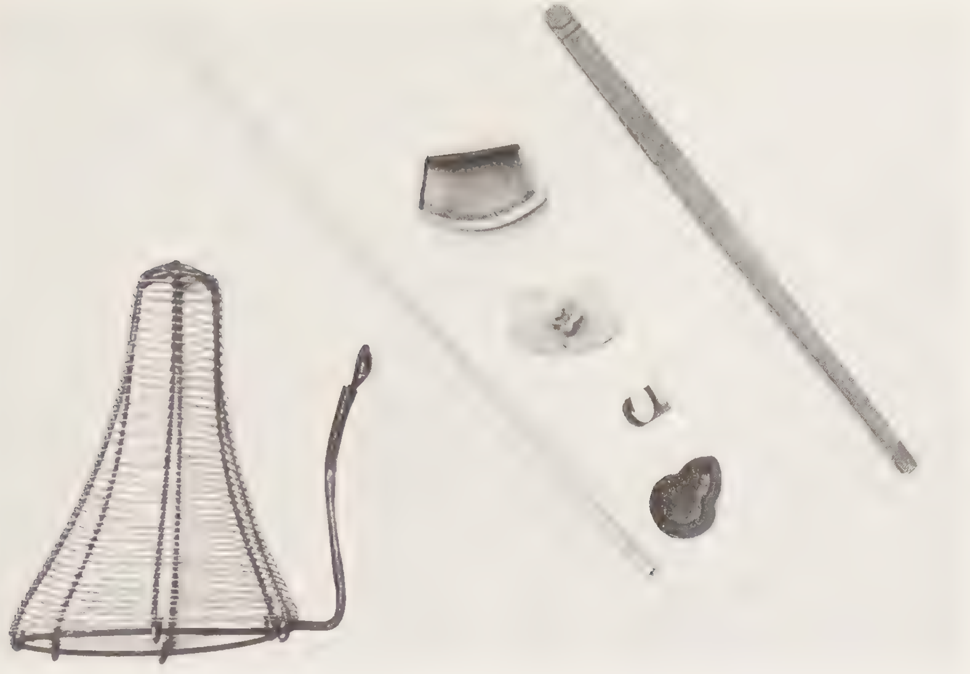
Honey-bee Family (*Apidae*). The best known species of this family is the common hive-bee, *Apis mellifera*. A winter colony of honey-bees may consist of 10,000 members, and a summer colony of 50,000. Nowhere else in the world of Nature is maternal egotism so marvelously developed as in the queen bee.

In each hive one queen, and only the queen, has the right to motherhood—a law of the bee world as unalterable as the laws of the Medes and Persians. If another queen appears, even though she be the ruling sovereign's own daughter, there is civil war, and one or the other must leave. Fifty thousand of her children must renounce maternity and vow themselves to celibacy, although they could, if they willed, lay parthenogenetic eggs from which female bees would hatch. Indeed, in queenless hives, a worker does for the moment take up the task of egg-laying until a real queen is hatched.

There are brood cells and food cells to be built, food to be stored, wax to be secreted, filth to be removed, younglings to be nursed, invaders to be repelled, currents of air to be kept circulating, and queens to be supported. If we were to visit a hive at swarming time, we would, if we listened well, hear a great commotion within. A daughter grub has been fed with royal jelly and has blossomed forth a queen. She is ready to dispute with the mother the scepter of that hive. A battle royal takes place. Mother and daughter each have their adherents. If one is not the victim of the other's sting, the worsted one—and usually it is the mother that is worsted—sets up a shrill piping. This is a call to her adherents to join in shaking the dust of that bee city from their feet, and to go where base ingratitude does not reign, but where peace may rule again.

The wax from which honeycomb is fabricated is a secretion that exudes through tiny pores in a series of small plates on the under side of the bee's abdomen. In order to secrete one ounce of this wax the bees must eat 20 ounces of honey. They fill themselves to the gullet, then hang in festoons from the ceiling.

By internal exertions they get warm enough to give the wax a liquid consistency as it oozes through the plates. Later it hardens, and then is removed, either by the manufacturer herself, or by another worker. After that it is kneaded and mixed with saliva with great care, and then put into the comb. In making brood comb, old wax may be used, but for honeycomb only new wax is employed. After the brood cells are made, the queen lays her eggs



Photograph by James Dorsett

EQUIPMENT USED IN HANDLING FIGHTING CRICKETS IN CHINA

In some parts of the Celestial Republic the sport of cricket fighting is as common as cockfighting in the countries of the Caribbean. At the left is the wire cage used for transferring the fighters to and from the ring. The light ferule next to the cage is the tickler, to stir up the fighters to a proper degree of anger. Beyond that are, respectively, from the bottom, the drinking trough, the food rack, the top of the cricket's house, and the house itself. At the right is a set of bamboo tweezers for handling food and equipment (see illustration, page 65).

in them. In three days these hatch into tiny larvæ, which are footless, helpless, soft-bodied grubs.

The nurses at once attend them, giving them as their first food a sort of pap or jelly formed in the nurses' stomachs and regurgitated for the grubs. After a few days, this diet is strengthened by the addition of a little honey and pollen to the menu. After a few days more, a bee bread made of honey and pollen is put into the cell, which then is sealed. After eating this, the grub falls into its transformation sleep, and slumbers for 13 days.

Then it awakens a full-fledged bee. But before it can go out into the open it must spend ten days or two weeks as an indoor worker, mayhap as a nurse, a scavenger, a ventilator, or each in turn. When the worker goes out she has the choice of drinking a given portion of nectar or of carrying it back to the hive. In front of her stomach is a honey sac. She fills this with nectar, carries it to the hive, regurgitates it into a honey cell or else into the mouth of an indoor worker.

Gradually the excess of water is evaporated, on the same principle that cane juice is boiled down into molasses. To render the honey antiseptic and to make it "keep," a tiny bit of formic acid is added to it by the bee. The pollen for the bee bread on which the indoor worker and the maturing larvæ feed is gathered from the flowers, tucked away in the pollen baskets on the bee's hind legs, and carried home.

It so happens that often, in hot weather, the natural condensation of the moisture of the hive is checked. At such times many workers transform themselves into winged water wagons, bringing water in their honey sacs to the thirsty ones in the hive. At other times material is needed to stop up the cracks and chinks in the hive—to keep out cold air—and they gather the resinous saps of various plants for mortar.

The ventilation of a hive is a fascinatingly interesting process. Workers arrange themselves on the floor and through the superstructure of the hive, and by a synchronized vibration of their wings set up air currents that expel the impure air and draw in the fresh, employing exactly the same principle that is used by mining engineers in keeping mines supplied with pure air.

One of the most pitiable spectacles in an apiary is to see a hive of bees thoroughly cowed by those of another hive, and standing by while the marauders carry out their honey. Ordinarily, there is a doughty guard at every

Photograph by Paul Henri Fabre

THE END OF A BATTLE BETWEEN SUITORS IN CRICKET LAND

The conquered suitor scampers away, while the conqueror insults him with a song of triumph. The lady cricket looks on very demurely from behind.

bee gate, and whoever would find stolen sweets within that gate may expect a drubbing such as pilferers deserve. But once in a while the occupants of a strong and lusty hive make a foray upon a weak one, and there is a bitter war in which the defenders are worsted. Once cowed by a mass attack, individual enemies seem able to maintain the terrorism, and to carry forward their pillaging at will.

The species reproduced is: Honey-bee (*Apis mellifera* Linn. Plate XII, figures 2, 4, and 9).

Melecta Bee Family (*Melectidae*). This family is made up of two groups, one of which is parasitic. The members of the parasitic tribe are true cuckoos. They have learned that well-known manner of living recorded in Holy Writ, "Reaping where thou hast not sown, and gathering where thou hast not strawed." Some of them single out some industrious species and take up quarters with them uninvited, eating the viands of their hosts as though they were honored guests instead of lazy spongers. Other cuckoo tribes resort to even a lower form of sponging. These watch around until some busy little mason-bee matron gets her nest well-nigh completed and provisioned; then, during her last trip for the final load of provender, they steal into the burrow and lay their eggs in the cell.

Unconscious of what has happened, poor Mrs. Mason-bee lays her egg and closes the cell. But the cuckoo-bee's eggs hatch first, and its larva, eating the ration that never was intended for it, presently grows strong enough to overpower and devour the rightful owner of the cell.

Some species of mason-bees, realizing the purposes of the cuckoos who flourish by nimble wit, never lay an egg in a cell without first having in their mouths the mortar with which to close the cell. If they had to gather the mortar after laying the egg, the plunderer would be the first to improve the opportunity of crossing the unguarded threshold and laying her own eggs in it.

"With the industrious folk who go quietly about their business—the laborers, masons, foragers, and warehousemen—mingle the parasitic tribe, the prowlers hurrying from one home to another, lying in wait at the doors, watching for an opportunity to settle their families at the expense of the honest toilers."

In those words Fabre sums up the situation in Bee Land. Then, bringing the detached view of the philosopher to man's own attitude toward other creatures, he makes one a little more patient with these home destroyers of the insect world by saying, "Life in general is but a vast brigandage.

"Nature devours herself; matter is kept alive by passing from one stomach to another. At the banquet of life, each is in turn the guest and the dish; the eater of to-day becomes the eaten of to-morrow. Everything lives on that which lived or has lived; everything is parasitism. Man is the great parasite, the unbridled thief of all that is fit to eat. He steals the milk from the lamb, he steals the honey from the children of the bee, even as the Melecta bee pilfers the pottage of the Anthophora bee's sons."

The species reproduced are: *Crocisa crucifera* Ckll. (Plate XII, figure 3), occurring in the Philippine Islands; *Triepeolus quadrifasciatus* Say. (Plate XII, figure 11), inhabiting North America.

Anthophora Bee Family (*Anthophoridae*). This family of bees is widely distributed throughout the world. In North America nearly 100 species have been described, but the habits of only a few of these have been studied. The nests of familiar species usually are built in steeply inclined or perpendicular banks of earth, preferably in those of compact clay. Nearly all of the species are gregarious, hundreds of individuals building their nests close together in the same bank of earth. In the construction of their homes the Anthophoras build a cylindrical tube of clay, extending outward and downward from the entrance of the tunnel.

The outside of this tube is rough, but the inside smooth. It is composed of small pellets of earth compacted together, which have been brought out of the tunnel when wet and molded into the desired form. In excavating the tunnel the bees find the clay hard, so they visit a watering place and convert themselves into insectean tanks to carry sufficient supply to the burrow to soften the clay and make it workable like putty.

The Anthophora bees have many foes, before whose attacks they are practically helpless.

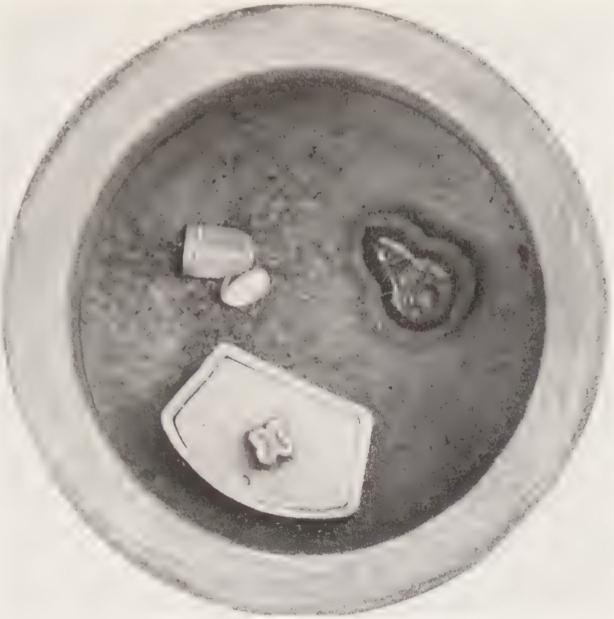
The species reproduced is *Anthophora zonata* Linn. (Plate XII, figure 5), found in southern Asia, Malay Peninsula, and Philippine Islands.

TRUE FLIES

(Order *Diptera*)

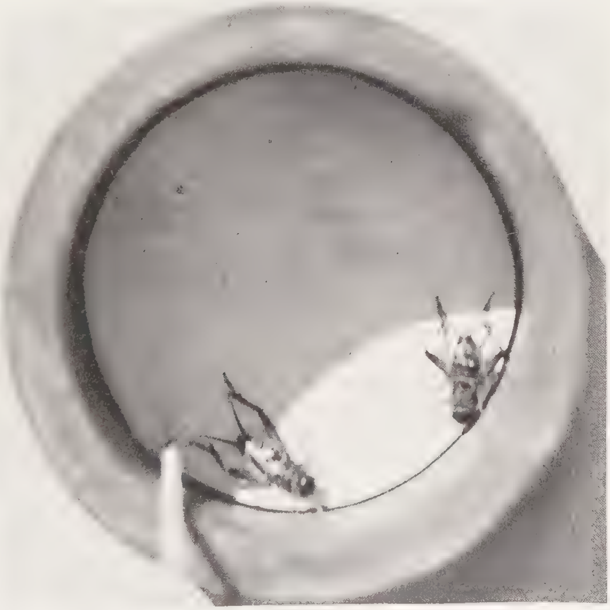
Plate XIV

This large order of insects embraces all the two-winged flies, which include the horse



A CHINESE CRICKET ARENA

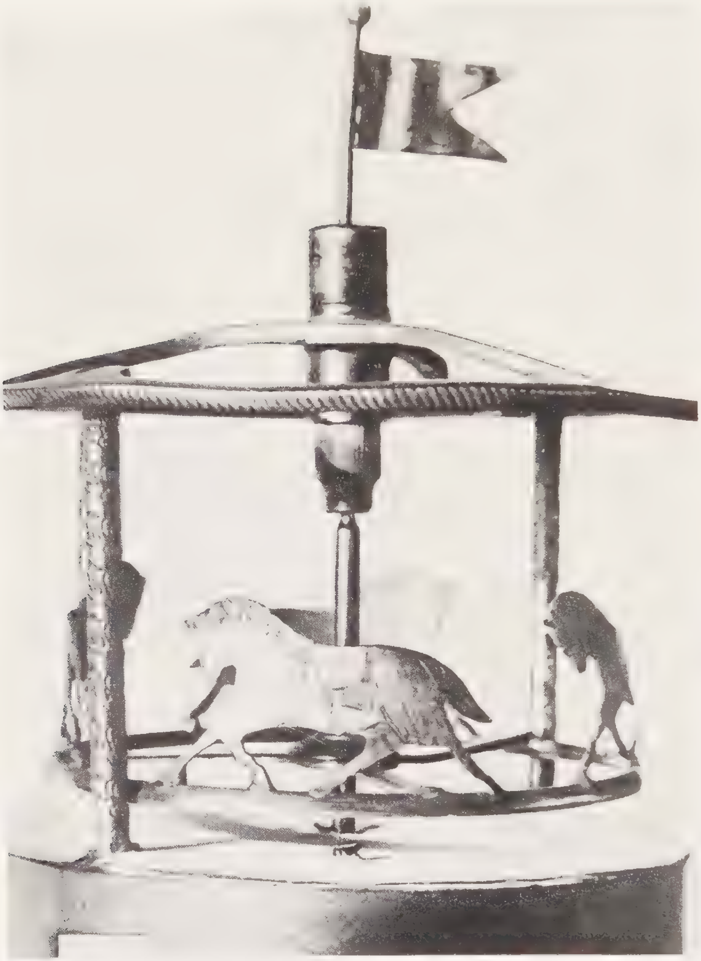
In the bowl is the cricket house with the lid on, at the upper left a food rack with a bean lying beside it, and at the upper right a water trough (see, also, page 63).



Photographs by James Dorsett

CRICKET GLADIATORS

The fighting ring is made of a portion of a large bamboo culm. Betting in China on the results is as lively as that at a horse race or at a game of *jai alai* in Cuba.



Photograph by International

A CHINESE MERRY-GO-ROUND DRAWN BY A FLEA

The tiny bit of motive power is seen in the foreground, under the rim of the wheel. Harnessed to the little toy, the insect is able to move eleven hundred times its own weight. In the United States men have trained fleas to draw tiny wagons and to do acrobatic stunts that make the flea circus a fascinating vaudeville performance.

flies, house-flies, blow-flies, mosquitoes, midges, and gnats, as well as a host of related families. According to Sharp, about 40,000 species have been discovered, but these are only a tithe of those still unknown to science. Aldrich's list of American species now goes far beyond the 8,000 mark.

The *Diptera* are rated by some authorities as physiologically the most advanced of the insects; certainly in them the processes of a complete life cycle are carried on with the greatest rapidity, and the phenomenon of metamorphosis has been most nearly perfected.

A maggot hatching from an egg grows so rapidly that it is mature in a few days; then within an impenetrable skin it dissolves itself almost completely. A little later the liquid content of that skin turns to a sort of jelly, and in a few days this is reconstructed into a being so totally different in appearance, in habits, and in structure, that the resources of science find themselves severely taxed to demonstrate any identity in the organs of the two stages of the insect's existence.

Hover Fly Family (*Syrphidae*). This family is one of the largest and best known among the flies. We see them in our garden, where, when the sun is bright, they hover over flowers or beneath trees where the sun finds its way through the leaves. Many of them mimic bumble-bees, others pattern after honey-bees, and still others imitate the wasps.

It is said that the old myth about the carcasses of animals generating swarms of honey-bees probably arose from the fact that one species of this family so closely resembles the drones that they have been taken for honey-bees. That species breeds in carcasses, and its mistaken identity is found in China and Japan, as well as in Russia. Even the Book of Judges in the Old Testament shows this error of identification in the story of Samson. The majority of species, however, are content to play the simple rôle of an ordinary fly.

The family embraces some 3,000 species distributed all over the world, of which about 300 are represented in our American fauna. Some species live as guests in ants' nests and others dwell with bumble-bees.

The species reproduced are: Tropical Hover Fly (*Volucella obesa* Fab. Plate XIV, figure 1), common throughout the American Tropics; Florida Ant Fly (*Microdon fulgens* Wiedemann. Plate XIV, figure 3), occurring in Florida; Eastern Hover Fly (*Temnostoma excentricum* Harris. Plate XIV, figure 9), living in the eastern part of the United States; *Milesia virginiensis* Drury. (Plate XIV, figure 10), inhabiting the eastern United States.

Pyrgota Fly Family (*Pyrgotidae*). The members of this family, by many authorities, are placed in the family of Ortalids. Some species of the family are parasitic upon various beetles.

The species reproduced is: May Beetle Fly (*Pyrgota undata* Wiedemann. Plate XIV, figure 2), parasitic upon the May beetle and found in the eastern United States.

Tachina Fly Family (*Tachinidae*). There is no family of the fly order to which man is more deeply indebted than to the Tachina. Its species are practically all parasitic in their habits. Frequenting the flowers and vegetation where other insects gather, they watch their chance to attach their eggs to the skins of young caterpillars and grubs.

When these eggs hatch, the larvæ bore into their victims and live on the tissues. Sometimes the victim is killed before pupation, but usually the parasite's attacks are not fatal so soon, and pupation takes place. Later the parasite grub itself pupates within the carcass of its victim and then emerges a full-fledged fly. Many species of this family help to hold in check the great hosts of army-worms, locusts, and other of our worst insect foes, which otherwise would overwhelm a community. A single species is almost the only check on the destructive flower-eating Diabrotica of California, which, Kellogg tells us, if allowed to increase unhindered, soon would destroy every blossom in that land of flowers.

Photograph by Paul Henri Fabre

THE LARVA OF A CICADA IN ITS BURROW

The females of innumerable species of insects lay their eggs in the ground. When these hatch the larvæ dig themselves burrows in which they remain, usually until a short time before they are ready to develop wings and fly away in the adult stage of their life cycle. Many other species lay their eggs in fruits, nuts, and branches. When these fall to the ground the larvæ emerge and dig into the soil, where they make cells in which they sleep until the metamorphosis is complete.

More than 1,400 American species have been reported in our fauna. Some species give birth to live larvæ instead of laying eggs. The skin of the prospective host is punctured by the viviparous female with her ovipositor and her larvæ deposited within the body of the host. In the case of *Eupeleteria magnicornis,* which infests the larvæ of the brown-tail moth, the female attaches its larva to the surface of a leaf by a thin membranous case which is cup-shaped and surrounds the anal end of the larva. The little maggot reposes on the silken thread which the caterpillar uses as a guide back to its nest, lying in wait until the victim returns from the feeding ground.

The species reproduced are: Eastern Tachina Fly (*Belvesia bifasciata* Fab. Plate XIV, figure 4), occurring in eastern and southern United States; Western Tachina Fly (*Paradejeania rutiloides* Jaennicke. Plate XIV, figure 5), inhabiting the western part of the United States.

Bot Fly Family (*Oestridae*). Although this family consists of fewer than 100 species in the whole world, it is one of much interest on account of the habits of its members, which, though large in size, live entirely at the ex-

Photograph by Lynwood M. Chace

BLACK-AND-WHITE PAPER WASPS IN THE DARK CORRIDORS BETWEEN TIERS OF CELLS

The wasps never have been able to solve the problem of a year-to-year existence of their colonies, as have some of the bees and ants. Each fall the community dies out, and only a few fertilized females, which have hibernated as adults in sheltered places, such as crevices in stone walls and protected spots under logs, are able to survive the winter. When spring comes these reawaken into an active life and make themselves small nests containing a few brood cells. From these humble beginnings the summer colonies grow.

pense of living vertebrates. Some dwell in the alimentary canals of their hosts, others occupy the respiratory passages, and still others live beneath the skin of the animals they attack. Some species of the bot fly family in the Tropics are parasitic on monkeys and even have been reared from human beings.

The Ox Warbles are aliens from Europe. They attach their eggs to cattle, usually on the hind legs and occasionally on the flanks. When the larvæ hatch they crawl down the hair follicle and penetrate the skin. In their second stage they are found in the wall of the esophagus. The exact course from the hind legs to the esophagus has not been determined, but it is believed that the larvæ probably travel in the loose connective tissues under the skin to the region of the throat and into the esophagus. Here they remain for three months and then migrate to the back, where they finally emerge through holes in the skin.

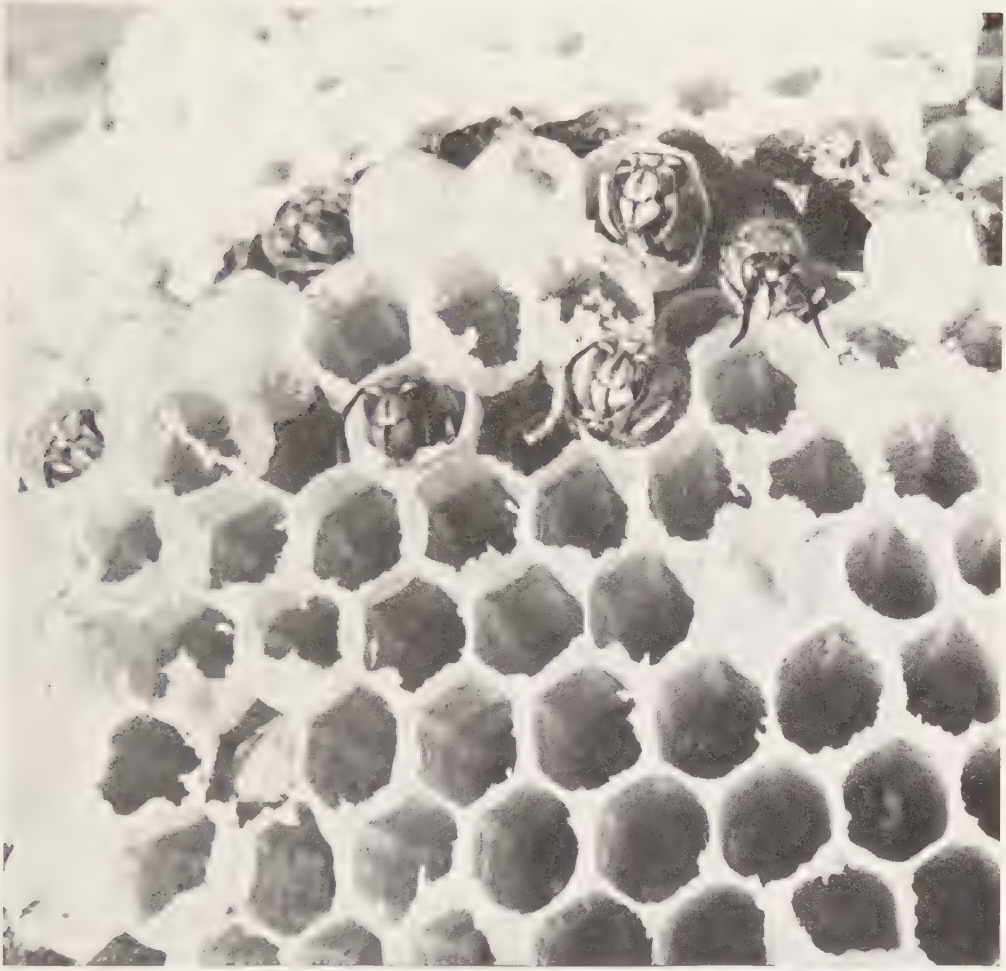
The horse bot fly is well known to every lover of horseflesh. During the summer time it flies about the forelegs of horses, laying its eggs on the long hairs above and below the knee joints.

These eggs rarely hatch when left untouched, but the horse, by scratching the legs with its teeth, removes the small cap of the eggshell and inadvertently takes the larvæ into its mouth. The latter then are carried with food or water into the stomach, where they fasten themselves to the inner coating and remain until full grown. Horses have an instinctive fear of the gad fly, as the adult more popularly is called.

The species reproduced are: Central American Bot Fly (*Dermatobia hominis* Linn. Plate XIV, figure 6), habitat Central America; Ox Warble (*Hypoderma lineatum* DeVilliers. Plate XIV, figure 8), occurring in eastern and southern United States.

Blow-fly Family (*Calliphoridae*). The most familiar members of this group are the blue-bottle and green-bottle flies. The blow-flies live normally out-of-doors, but often enter houses in search of material on which to deposit their eggs. Their larger size and loud buzzing, as well as their striking hues, make them conspicuous in any fly company. They lay their eggs on meat, cheese, and other provisions. These soon hatch and their larvæ rapidly develop.

It seems rather strange that until only a few centuries ago maggots were supposed to be the product of spontaneous generation. Then some early scientist decided to spread a piece of fly



Photograph by Lynwood M. Chace

CELLS OF A BLACK-AND-WHITE PAPER WASP

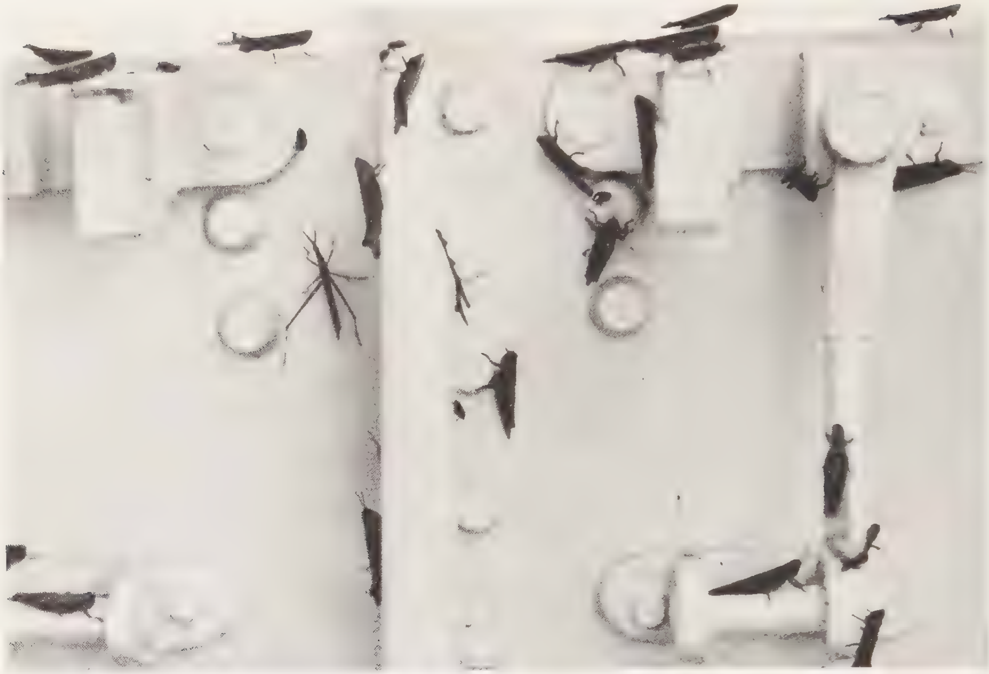
From some of the cells the young wasps have emerged, in others they are getting their first view of the world round about, and in still others the occupants remain undisturbed by the events of their community. The seals of their living tombs have not yet been broken, but presently the day of emergence will arrive, and, biting away the coverings, they will come forth full-panoplied for a short and merry life of a few weeks.

netting above a block of cheese so that the flies could hover about the cheese but not reach it. They thereupon laid their eggs upon the netting and these in due time produced the usual larvæ of maggots, and the ghost of spontaneous generation was banished for a long time. But when bacteria were discovered it came back, and so strenuously asserted itself that faith in it was held firmly in many quarters until Pasteur, through a long series of experiments, thoroughly put it to rout as an explanation even of the minutest form of life.

The species reproduced are: Scavenger Fly (*Silbomyia fuscipennis* Fab. Plate XIV, figure 7), from Java; Costa Rican Blow-fly (*Mesembrinella umbrosa* Aldrich. Plate XIV, figure 14), from Costa Rica.

Robber Fly Family (*Asilidae*). More than 3,000 robber fly species have been described, of which 500 are found in our fauna. Some are short, thick, and extremely hairy, superficially resembling bees and bumble-bees, but the majority of them are long and slender. As is the case with most insects which feed upon other insects, the robber flies are a ravenous host. A single individual has been observed to kill eight moths in 20 minutes.

They are fierce foes and seem to fear nothing. The stronger species will attack wasps and other stinging insects, and have been observed to capture dragon-flies and tiger-beetles. The larvæ of most species are like the adult flies in their predaceous habits. They feed upon



Photograph by Herbert

GRASSHOPPER GUESTS OF THE U. S. S. "MINDANAO"

When America's new Yangtze River gunboat reached a point a thousand miles from the Yellow Sea, a huge swarm of grasshoppers swooped down, rested a while, and then took wing again. Many species of insects have colonized the whole world by becoming stowaways aboard the ships that sail the seven seas.

other larvæ in rotting wood, under bark or fallen leaves, or in loose soil.

The species reproduced is: California Robber Fly (*Laphria coquilletti* McAtee. Plate XIV, figure 11), found in California.

Nimble Fly Family (*Dexiidae*). This family possesses about 50 species in this country. The legs of the American species are usually long, and in their early stages our nimble flies are parasitic on various insects, especially beetles. Snails also are known to be forced to act as hosts for their larvæ.

The species reproduced is: Australian Nimble Fly (*Rutilia splendida* Donovan. Plate XIV, figure 12), found in Queensland, Australia.

Ortalid Family (*Ortalidae*). This is a small family which possesses a number of American species. In the larval state they usually occur under the bark of pine and poplar trees, in the burrow of wood-boring insects, and in onions, cotton bolls, and apples. Most species are regarded merely as scavengers, but some are parasitic on caterpillars.

On the whole, the American Ortalids are a group of insects that have few foes and many friends.

The species reproduced is: *Achias amplividens* Walker. (Plate XIV, figure 13), occurring in Australia.

THE LITTLE MOTHS

(Order *Micro-lepidoptera*)

Plates XV and XVI

Among the *Micro-lepidoptera* are some of the worst pests of the whole insect world. The Psyche moth, which in its larval stage is known as the bagworm, belongs to this order. So do the green slug-moth, with its bright scarlet caterpillar; the hag-moth, which gets its name from the disheveled appearance of its larva; the raspberry root-borer and the peach-tree borer, which are such foes of the berry patch and the peach orchard; the bee-moth, the flour- and meal moths, the clothes-moth, the codling moth, and many others of their ilk.

Olethreutidae Family. More than 400 North American species of this family have been described. Perhaps its most disliked member is the codling moth, whose larvæ are the nasty little worms too frequently found feeding near the core of apples. The grape berry moth, which is the most common cause of "wormy" grapes, also belongs to this group, as do the apple bud moth and the clover seed moth.

The species reproduced are: European Pine Shoot Moth (*Rhyacionia buoliana* Schiffermuller. Plate XV, figure 1), a native of Eu-

Photograph by Paul Henri Fabre

LONG-HORNED BEETLES ON A LOG

Some wood-boring beetles spend their larval stage in the heart of oak trees, while others spend this period driving mines between the bark and the wood. The latter species are known as engraver beetles. One tiny member of the order has been a source of much trouble to transcontinental telephone cables. They bore through the lead sheathing, thereby admitting moisture and destroying the insulation.

rope, also found in New York; Virginia Pine Moth (*Petrova virginiana* Busck. Plate XV, figure 3), found in Virginia and eastern United States; *Grapholitha egregiana* Felder. (Plate XV, figure 16), found in the Solomon Islands.

Oecophoridae Family. The *Oecophoridae* moths embrace about 100 American species of rather diverse habits, most of which, in their larval stages, live in webs or feed in decayed wood. Perhaps the most familiar species is the parsnip web moth, whose larvæ web together and devour the unfolding flower heads of celery, parsnip, and wild carrot. After having consumed the flowers and unripe seeds and become nearly full-grown, they burrow into the hollow stems of the plants, feed upon the pith and then pupate.

The species reproduced are: *Lupercalia ignita* Busck. (Plate XV, figure 2), occurring in Panama; *Filinota hermosella* Busck. (Plate XV, figure 6), habitat French Guiana; *Phytomimia chlorophylla* Walsingham. (Plate XV, figure 18), inhabiting Guatemala; *Hypercallia miniata* Dognin. (Plate XVI, figure 4), habitat Ecuador.

Cosmopterygidae Family. In spite of the fact that this family has no common name, some of its members are well known. One of these is the Palmetto Leaf-miner, which lives on the saw palmetto. Its larvæ are social, working together in small companies. They make nests consisting of a delicate sheet of silk covering that part of the leaf upon which they are feeding. The cattail moth, which infests the heads of cattail plants, is another member.

The species reproduced are: *Psacaphora edithella* Barnes & Busck. (Plate XV, figure 4), occurring in Colorado; Palmetto Leaf-miner (*Homaledra heptathalama* Busck. Plate XV, figure 5), inhabiting Florida.

Gelechiidae Family. This family includes a number of our worst pests and possesses more than 400 species. Some are leaf-miners, others attack the heads and bolls of plants, and still others prey upon stored grain. The Angoumois grain-moth, whose larvæ feed within the seeds of oats, rye, wheat, barley, sorghum, and cow peas, and the pink boll worm, which is one of the worst of our insect pests, are the outstanding members of the family. The peach twig borer, which burrows into the tender shoots of the peach tree in early spring, and the goldenrod gall moth, whose larvæ cause the galls in the stems of goldenrod, also belong to this group of *Micro-lepidoptera*.

The species reproduced are: *Atasthalistis tricolor* Felder. (Plate XV, figure 7), living in

Photograph by Paul Henri Fabre

TWO INSECT WEATHER PROPHETS CONFER (SEE TEXT, PAGE 14)

These green grasshoppers are close relatives of the katydids. The males sing both by day and by night. The eggs of most species are laid usually in the stems of root leaves of grasses or the pith of twigs.

the Solomon Islands; *Atasthalistis concinnalis* Feisthamel. (Plate XVI, figure 3), occurring in New Guinea.

Hyponomeutidae Family. This is another family of *Micro-lepidoptera* which is somewhat noted for its pest species. One of them is the apple fruit miner, which has developed into a serious menace in orchards in western Canada. It burrows in all directions through the fruit, causing it to decay. The family also embraces the ailanthus web-worm moth and the ermine moth. One species of the latter has been introduced into the United States and is becoming an apple and cherry pest.

The species reproduced are: *Mieza citrina* Busck. (Plate XV, figure 8), living in Costa Rica; *Mieza laetae* Hubner. (Plate XV, figure 10), occurring in Guatemala; *Mieza spatula* Busck. (Plate XV, figure 11), living in Costa Rica; *Atteva exquisita* Busck. (Plate XV, figure 13), a native of Mexico; *Atteva hysginiella* Wallengreen. (Plate XV, figure 17), inhabiting the Galápagos Islands; *Atteva pustulella* Fab. (Plate XV, figure 20), an inhabitant of San Salvador; *Lactura conflagrans* Walker. (Plate XVI, figure 2), occurring in New Guinea; *Pseudotalara regia* Schaus. (Plate XVI, figure 5), occurring in Mexico.

Glyphipterygidae Family. This family is of world-wide distribution. There are about 40 species which belong to it in the North American fauna.

The species reproduced are: *Tortyra cuprinella* Busck. (Plate XV, figure 9), occurring in Panama; *Hemerophila albertiana* Stoll. (Plate XV, figure 12), native of British Guiana; *Mictopsichia durranti* Walsingham. (Plate XV, figure 19), native of Guatemala.

Adelidae Family. The tiny moths of this family in their larval stage feed on the leaves of various herbs and shrubs. In their earliest stages the larvæ are miners, but later they live in portable cases. The male members of the family are characterized by the unusually long and fine antennæ, which may be twice or more than twice the length of the wings.

The species reproduced is: *Nematois chrysoprasias* Meyrick. (Plate XV, figure 14), occurring in Assam.

Ethmiidae Family. The larvæ of this family are usually social, living in a light web and feeding chiefly on plants of the borage family. Most of the American species belong to the genus *Ethmia*.

The species reproduced is: *Ethmia festiva* Busck. (Plate XV, figure 15), found in Guatemala and Panama.

Tineidae Family. Some 4,000 species of this family, which includes among others the

Photograph by Paul Henri Fabre

A BEETLE DRAGS A CICADA INTO ITS BURROW

The most striking hunters of the insect world belong to the wasp clan. However, many of the beetles are also carnivorous.

clothes-moths and many of the leaf-miners, have been described, of which 125 have a North American habitat. Each of the three species of clothes-moths belongs to a different genus, and all of them came with the American people from the Old World. One of them is the parent of the case-bearing larva.

Whenever this larva grows too large for its little case, it expands its home without emerging therefrom. Cutting a triangular slit down one side, in the one end it inserts triangular gores of the woolen material upon which it is feeding, after which it turns around and enlarges the other end in the same way. That process takes care of the diameter, but not the length of the case. To make it longer, each end is opened and an addition is built.

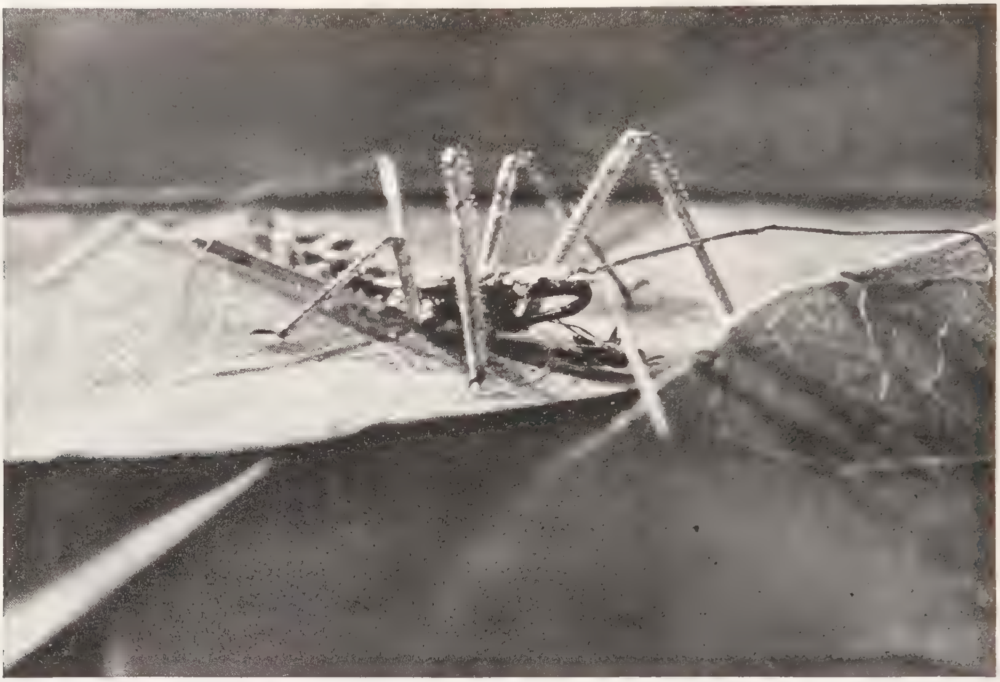
The web clothes-moth makes no case, but hides in a fold or crevice of the material it is eating and spins a little web of silk to cover it. The third species is found in fur robes, horse blankets, upholstering, and the like. Species of the genus *Stigmella* are mostly leaf-miners. The leaves of Juneberry, oak, chestnut, hazel, walnut, sycamore, ironwood, apple, wild cherry, sweetbrier, and blackberry each have their own special species of these miners.

The species reproduced is: *Coryptilum klugii* Zeller. (Plate XVI, figure 1), found in New Guinea.

Tortricidae Family. This large family, mostly made up of leaf-rollers, possesses about 165 North American species. The *Cacoecia* include the rose ugly nest, the cherry tree ugly nest, the oak ugly nest, and the fruit tree ugly nest, the latter being much of a nuisance in orchards. The eggs are laid on the bark of the twigs in June. The larvæ hatch in May of the following year and enter the opening buds.

The species reproduced are: *Cerace onustana* Walker. (Plate XVI, figure 6), found in Japan; *Pseudatteria leopardina* Butler. (Plate XVI, figure 7), occurring in Costa Rica; *Pseudatteria mimica* Felder. (Plate XVI, figure 9), habitat Brazil; *Megalodoris electrina* Meyrick. (Plate XVI, figure 12), living in the Philippine Islands; *Tortrix animosana* Busck. (Plate XVI, figure 14), occurring in Guatemala.

Clear Winged Moth Family (*Aegeriidae*). This is a small family of unorthodox *Microlepidoptera*, since many of them have no scales on their wings and some of them only a few. Likewise they depart from the moth habit in being day rather than night flyers. The majority of the species of the family mimic bees, wasps, and flies. This mimicry is not a superficial one, since even the motions of the insects captured or disturbed closely resemble those of the ones they imitate. Their attitude while resting, the sounds they produce, their hyaline wings, the rings on their bodies, even the odors they give off, stamp them as being what they are not. Some of them carry the deception so far that they even pretend to sting, and go



Photograph by Paul Griswold Howes

AN ASSASSIN-BUG FEEDING ON A CAPTURED INSECT

These hairy-legged creatures feed mainly on other insects, but have been known to bite human beings. The kissing bugs, which occupied so much space in the newspapers several decades ago, belong to this family. The hairs on their bodies are often sticky, and particles of dust, lint, and other material adhere to them, practically concealing them. Its appearance has given to one of the species the common name of masked bed-bug hunter (see text, page 41).

through all the motions of doing so, although they are entirely lacking in the necessary organ for that purpose.

The larvæ of the family are all borers. One of them, *Sanninoidae exitiosa*, is the worst of all the peach-tree borers, and is estimated to damage the peach crop to the extent of $6,000,000 a year. While it formerly preyed on wild cherries and plums, it later adopted the peach tree.

The species reproduced are: *Paranthrene palmi* Harry Edwards. (Plate XVI, figure 8), occurring in New York State; Western Clear Winged Moth (*Melittia gloriosa* Harry Edwards. Plate XVI, figure 11), living in Oregon.

Plutellidae Family. This family is of wide distribution, with about 50 North American species. The most familiar member is the diamond back moth whose larvæ infest cabbage and other cruciferous plants, eating holes in the leaves. The moth is sometimes a pest in greenhouses, infesting stocks, wallflowers, sweet alyssum, and candytuft.

The species reproduced is: *Imma grammozona* Meyrick. (Plate XVI, figure 10), habitat New Guinea.

Stenomidae Family. This family possesses some 20 North American species and has a rather wide distribution. The larvæ live in webs, most frequently infesting the oak.

The species reproduced are: *Stenoma elegans* Zeller. (Plate XVI, figure 13), occurring in Peru; *Stenoma armata* Zeller. (Plate XVI, figure 15), inhabiting Paraguay.

THE BEETLES

(Order *Coleoptera*)

Plates XVIII to XXIV inclusive

The beetles are the predominant order of the insect world. The transformation of what was once their forward pair of wings into wing cases makes them poor flyers, but it gives them a protection that has brought prosperity to their kind. The order consists of about 150,000 known species, which are grouped in upward of 80 families. Although representatives of nearly all of these families are to be found in our fauna, less than 40 families contain the species that are familiar to most of us. Among the families not illustrated are those to which belong the fireflies, curculios, bark-beetles, grain beetles, burying beetles, death-watch and drug-store beetles, rove beetles, water pennies, and whirligigs.

Tortoise Beetle Family (*Cassididae*). These beetles get their name from the striking

Photograph by George R. King

TENT-CATERPILLAR NESTS IN WESTCHESTER COUNTY, NEW YORK

The larvæ of many species of moths, butterflies, and *Micro-lepidoptera* are gregarious in their habits and build community nests, where they stay together until time to pupate. Then they become individualistic again and each goes its own way.

similarity of their shape to that of the tortoise. Many of them possess striking colors in life which incline to fade in death. To this family belong the striking argus and the brilliant gold-bug. Beautiful as are the adults, their grubs are ugly and disagreeable in the extreme. They possess taillike forks at the end of the body, upon which is heaped their excrement and cast skins, used as a sort of shelter.

Each successive molt brings a new cast skin to the shelter, which gradually comes to resemble a pack, so that the grubs become known as peddlers. The gold-bug seems to possess some of the characteristics of the chameleon. Sometimes it appears in a dull yellow costume and at others in an armor that shines like burnished gold. At still other times it is arrayed so that it presents the variable tints of pearls.

The species reproduced are: *Desmonota variolosa* Web. (Plate XVIII, figure 1), from Bahia; *Tauroma casta* Boh. (Plate XVIII, figure 4), native of Costa Rica; *Omaspides bistriata* Boh. (Plate XVIII, figure 15), occurring in Colombia, Venezuela, and Costa Rica; *Dolichotoma bisbiplagiata* Boh. (Plate XVIII, figure 16), habitat Guatemala; *Aspidomorpha miliaris* Fab. (Plate XVIII, figure 17), habitat the Philippines, New Guinea, Yünnan, and Tonkin; *Mesomphalia beatula* Boh. (Plate XVIII, figure 21), occurring in Brazil.

Leaf Beetle Family (*Chrysomelidae*). There are some 18,000 known species in this family, nearly 1,000 of which occur in our North American fauna. It includes the long-horned leaf beetles, the 3-lined potato-beetle, the asparagus beetle, the grape root worm, and the familiar Colorado potato beetle. The latter is the largest species of the family, and the damage it does to potato leaves is typical of the ravages of the family on different forms of foliage on which the several species feed.

The story of the spread of the Colorado beetle constitutes one of the most surprising adventures of an insect species in American entomological history. When civilization moved west to Colorado it found there, feeding on sand burs, a yellow- and black-striped beetle with a disgusting odor, but with no hint of its deadly possibilities.

About 1850 it began to cultivate a taste for potato leaves; nine years later it had spread to Nebraska, reached Iowa at the beginning of the Civil War, and crossed the Mississippi the summer that Lee surrendered at Appomattox. It then spread eastward, and by the centennial year had succeeded in forcing the barriers of the Alleghenies and reaching the Atlantic seaboard. Europe was heartily alarmed when a few of them sailed across the Atlantic as stowaways, but prompt preventive measures and rigid quarantine have prevented them from colonizing the world's principal potato-growing continents.

The species reproduced are: *Leptinotarsa 10-lineata* Say. (Plate XVIII, figure 2), habitat Canada to Costa Rica; *Leptinotarsa flavitarsis* Guer. (Plate XVIII, figure 3), occurring in Guatemala; *Lema trilineata* Oliv. (Plate XVIII, figure 9), habitat North America and the West Indies; *Doryphora flavozonata* Blanch. (Plate XVIII, figure 18), habitat Bolivia; *Doryphora kollari* Stal. (Plate XVIII, figure 19), occurring in Brazil; *Doryphora mirabilis* Stal. (Plate XVIII, figure 20), habitat Mexico and Guatemala; *Doryphora flavozonata* Blanch. (Plate XIX, figure 1), native of Bolivia; *Sagra Borneoensis* Lac. (Plate XIX, figure 2), native of Borneo, and ranging all through the oriental region; *Sagra fabricii* Lac. Plate XIX, figure 10), habitat Java.

Metallic Wood-borer Family (*Buprestidae*). There are some 5,000 known species of metallic wood-borers, or Buprestids, in the world, of which about 200 are found in America. Many of them are among our most showy beetles, their metallic wing cases often being rich in brilliant iridescence. The wing cases of some eastern species are a brilliant green, and are used for dress trimmings. South American Indian chieftains often make anklets of the bronze wing cases of a gigantic South American species.

The larvæ of the larger species of Buprestids are nearly all wood-borers. They usually live under bark, and make broad, shallow burrows, galleries, and chambers.

So regular are their habits of burrowing that a trained entomologist can recognize the species that made the traceries long after they are gone, just as a bank teller recognizes the signature of a customer. Their bodies are long, somewhat flattened, the forward segments so joined with the small head as to make them appear to possess large, flat heads—hence their popular name of hammer-heads and flat-headed borers.

The most injurious of the Buprestid beetles is the flat-headed apple-tree borer, which prefers apple trees, but makes itself at home in many other kinds. The adults appear about May, and are a dull, metallic brown, except the abdomen, which is a rich, metallic greenish blue. The young larvæ build their nests in the soft sapwood, but as they grow older, bore deeper into the heartwood where they hibernate. In the spring, they bore back almost to the surface, where they build their pupal cells in which to undergo the sleep out of which they shall awaken full-fledged beetles.

Another injurious Buprestid is the peach-tree borer. With wing cases that look like hammered copper, it is a beautiful creature. Still another is the red-necked cane-borer which causes the "gouty galls" on blackberries and raspberries. The adults emerge in May or June, and lay their eggs where the leaf axil joins the stem. Their larvæ girdle the stem, and by early August the galls begin to form, if the girdling operation has been successful.

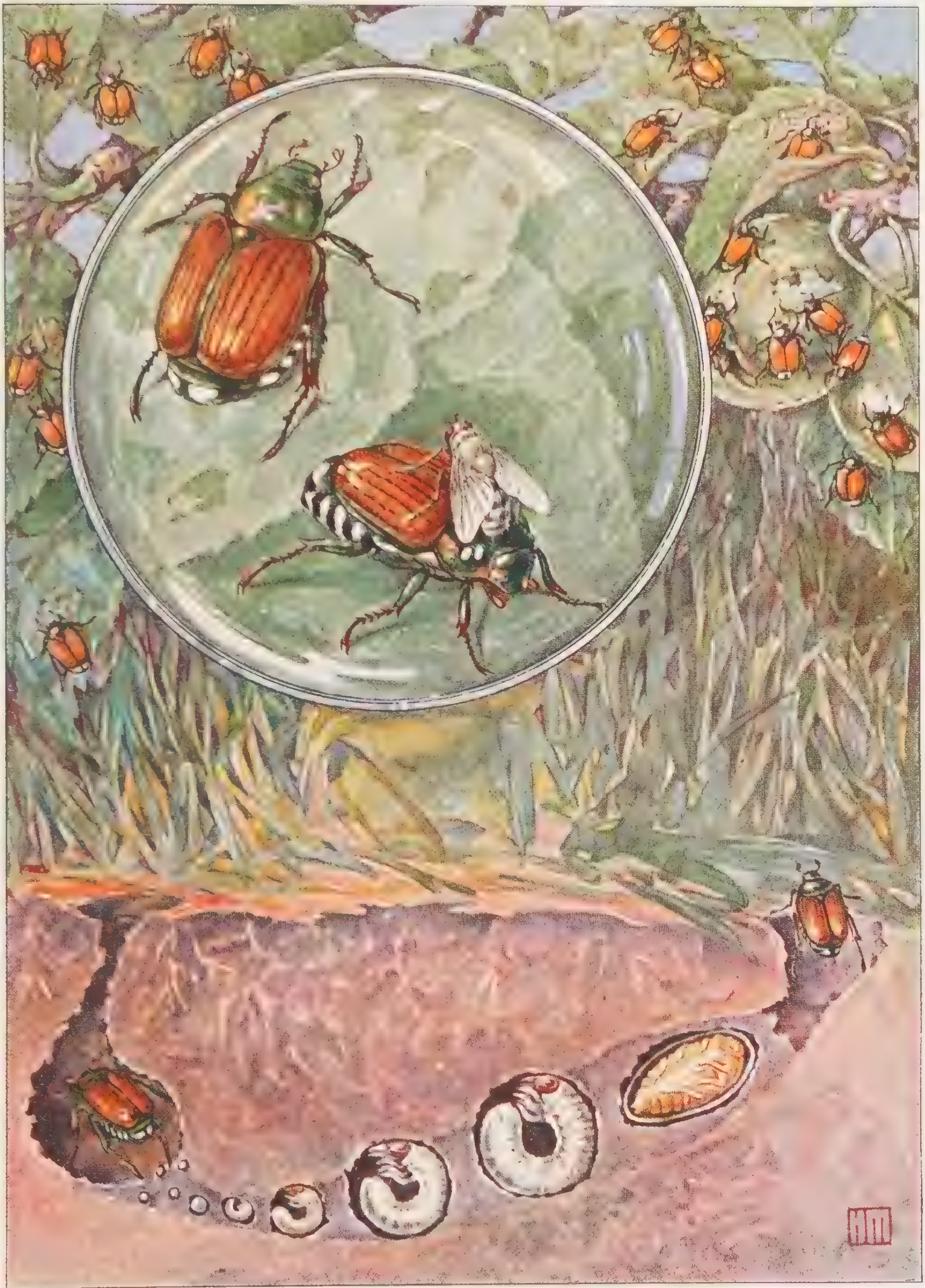
The larvæ spend the winter in the gall, or, if none has been formed, burrow into the pith of the brier stem. Many of the larger American Buprestids are particularly fond of pine trees, and prey on conifers exclusively. Some of the smaller species are leaf-miners.

The species reproduced are: *Chrysobothris femorata* Oliv. (Plate XVIII, figure 5), a North American species; *Julodis viridipes* Cast. (Plate XIX, figure 5), occurring in Africa; *Hyperantha haemorrhoa* Fairm. (Plate XX, figure 6), a South American species, living especially in Venezuela; *Psiloptera bicarinata* Thunbg. (Plate XX, figure 7), occurring in French Guiana; *Stigmodera variabilis* Don. (Plate XX, figure 8), habitat Australia; *Buprestis rufipes* Oliv. (Plate XXI, figure 2), habitat eastern United States; *Buprestis aurulenta* Linn. (Plate XXI, figure 3), occurring in northwestern United States; *Chrysochroa fulgidissima* Schoenh. (Plate XXI, figure 14), a Japanese species; *Sternocera bennigseni* Kerrem. (Plate XXII, figure 1), habitat Africa; *Sternocera hunteri* Waterh. (Plate XXII, figure 3), habitat Africa; *Conognatha amoena* Kirby. (Plate XXII, figure 4), habitat Brazil; *Belionota sumptuosa* Cast. & Gory. (Plate XXII, figure 6), habitat Malaysia; *Chrysochroa buqueti* Gory. (Plate XXII, figure 7), habitat Indo-China and Java; *Chrysochroa edwardsi* Hope. (Plate XXII, figure 8), occurring in southern Asia; *Stigmodera macularia* Donovan. (Plate XXII, figure 9), habitat Australia; *Chrysochroa ocellata* Fabricius. (Plate XXII, figure 10), habitat southern Asia; *Stigmodera suturalis* Donovan. (Plate XXII, figure 11), an Australian species.

Meloid Beetle Family (*Meloidae*). The Meloid beetles, of which there are some 1,500 known species, including the 200 that are American, have a fascinating life history. Some species prey on bees, others on locusts, and still others on divers forms of insect life. The one parasitic on locusts lays its eggs in spots frequented by the locusts. In a few days these hatch, and the baby Meloes proceed early and actively with their prime business of finding a host. Crawling around in large numbers, locust egg deposits soon are found, and presently most of the eggs become provender for the wandering host. After a preliminary feast the youngster makes seven different changes before reaching the adult stage. At one point a change results in a retrogression in its climb to adulthood.

The species reproduced are: *Epicauta vittata* Fab. (Plate XVIII, figure 6), found in North America; *Tegrodera aloga* Skinn. (Plate XIX, figure 7), habitat California; *Zonabris oculata* Thunbg. (Plate XIX, figure 8), a South African species.

Long-horned Beetle Family (*Cerambycidae*). There are about 13,000 species of long-horned beetles in the world, of which some 600 belong to North America. They include such pests as the round-headed apple-tree borer, the oak pruner, and the twig girdler.



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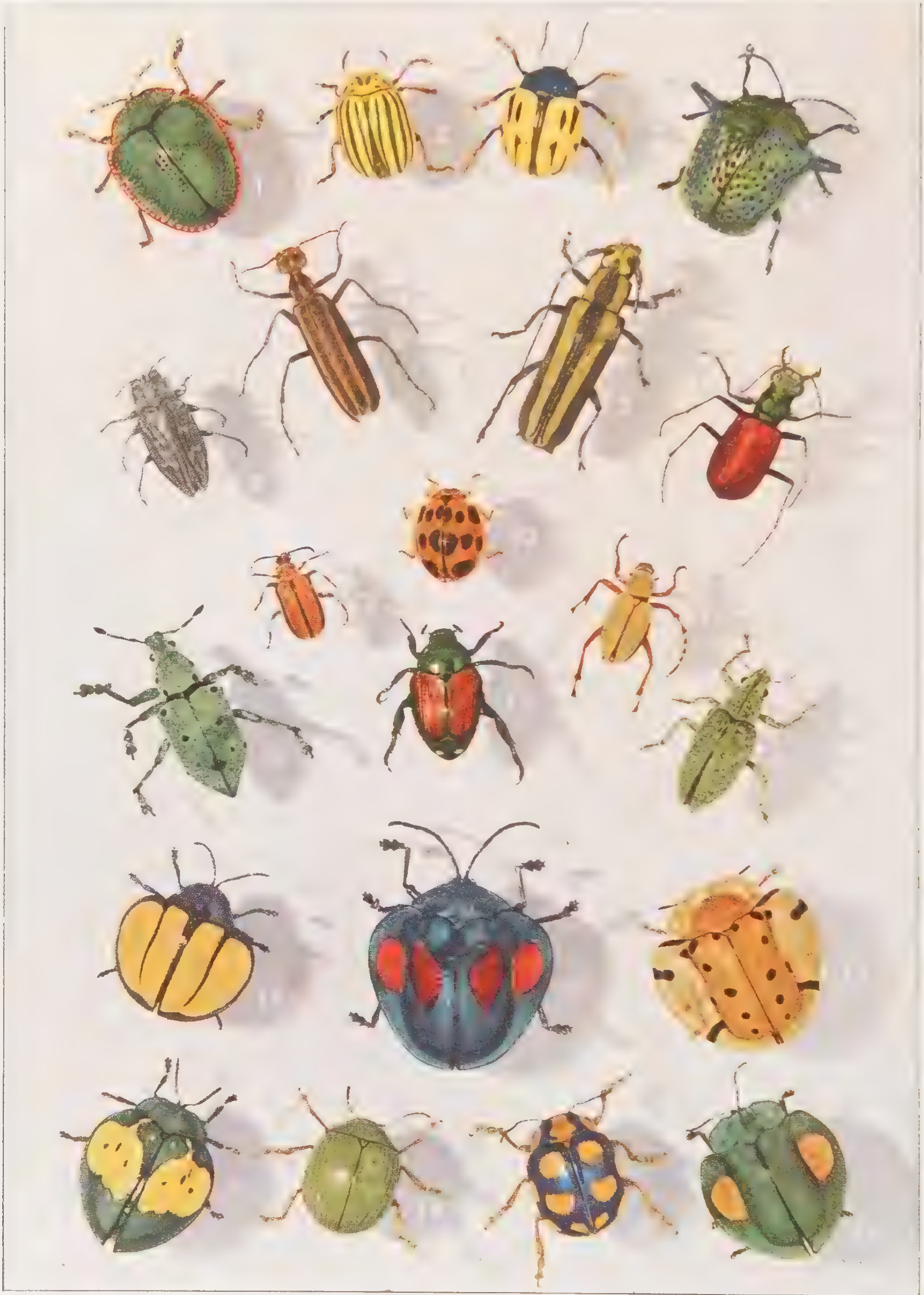
Painting by Hashime Murayama

THE JAPANESE BEETLE AND THE HIGH SPOTS OF ITS CAREER

The story of the career of this newest of our American pests is broadly typical of the whole Beetle Order. Not all of them spend their larval stages in the ground, however. The parasitic fly shown on the magnified female beetle was imported by the United States Bureau of Entomology. In Japan it and other parasites have been able to prevent the beetle from becoming a menacing pest. The entomological name of the Japanese beetle is *Popillia japonica* and of the fly parasitizing it *Centeter cinerea*. The beetles at the top of the main picture are natural size; those under the magnifying glass are 4½ times natural size; those at the bottom are 1½ times natural size.



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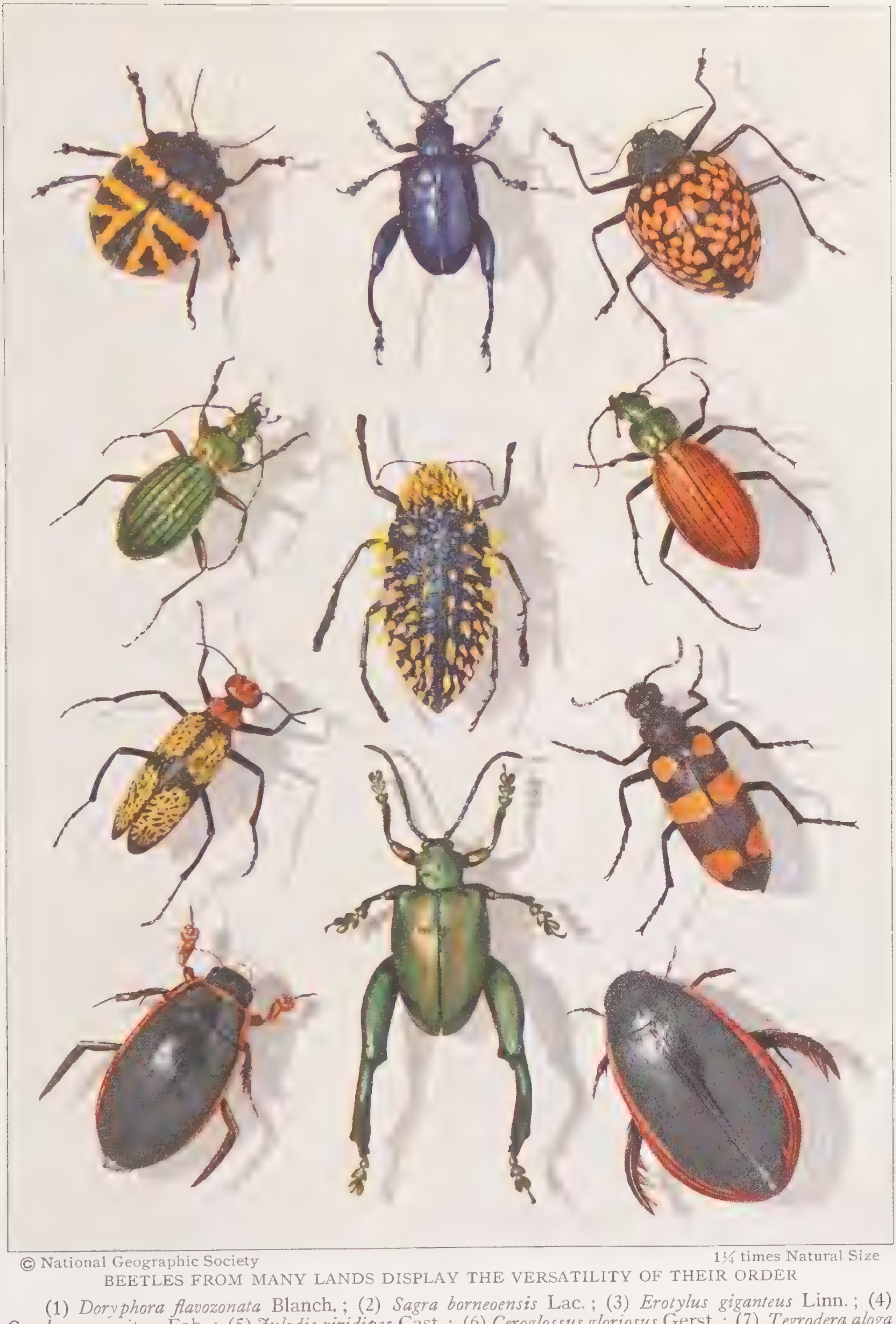
Twice Natural Size

LIVING JEWELS THAT MOCK THE LAPIDARY WITH THEIR BEAUTY

(1) *Desmonota variolosa* Web.; (2) *Leptinotarsa 10-lineata* Say; (3) *Leptinotarsa flavitarsis* Guer.; (4) *Tauroma casta* Boh.; (5) *Chrysobothris femorata* Oliv.; (6) *Epicauta vittata* Fab.; (7) *Saperda candida* Fab.; (8) *Cicindela scutellaris* Say; (9) *Lema trilineata* Oliv.; (10) *Epilachna borealis* Fab.; (11) *Macrodactylus angustatus* Beauv.; (12) *Cyphus 16-punctata* Linn.; (13) *Popillia japonica* Newman; (14) *Hypomeces squamosus* Fab.; (15) *Omaspides bistriata* Boh.; (16) *Dolichotoma bisbiplagiata* Boh.; (17) *Aspidomorpha miliaris* Fab.; (18) *Doryphora flavozonata* Blanch.; (19) *Doryphora kollari* Stal.; (20) *Doryphora mirabilis* Stal.; (21) *Mesomphalia beatula* Boh. See text under the following Family headings: Tortoise Beetle, Leaf Beetle, Metallic Wood-borer, Meloid Beetle, Long-horned Beetle, Tiger-beetle, Lady-bird Beetle, Scavenger Beetle and Leaf Chafer, and Snout Beetle.



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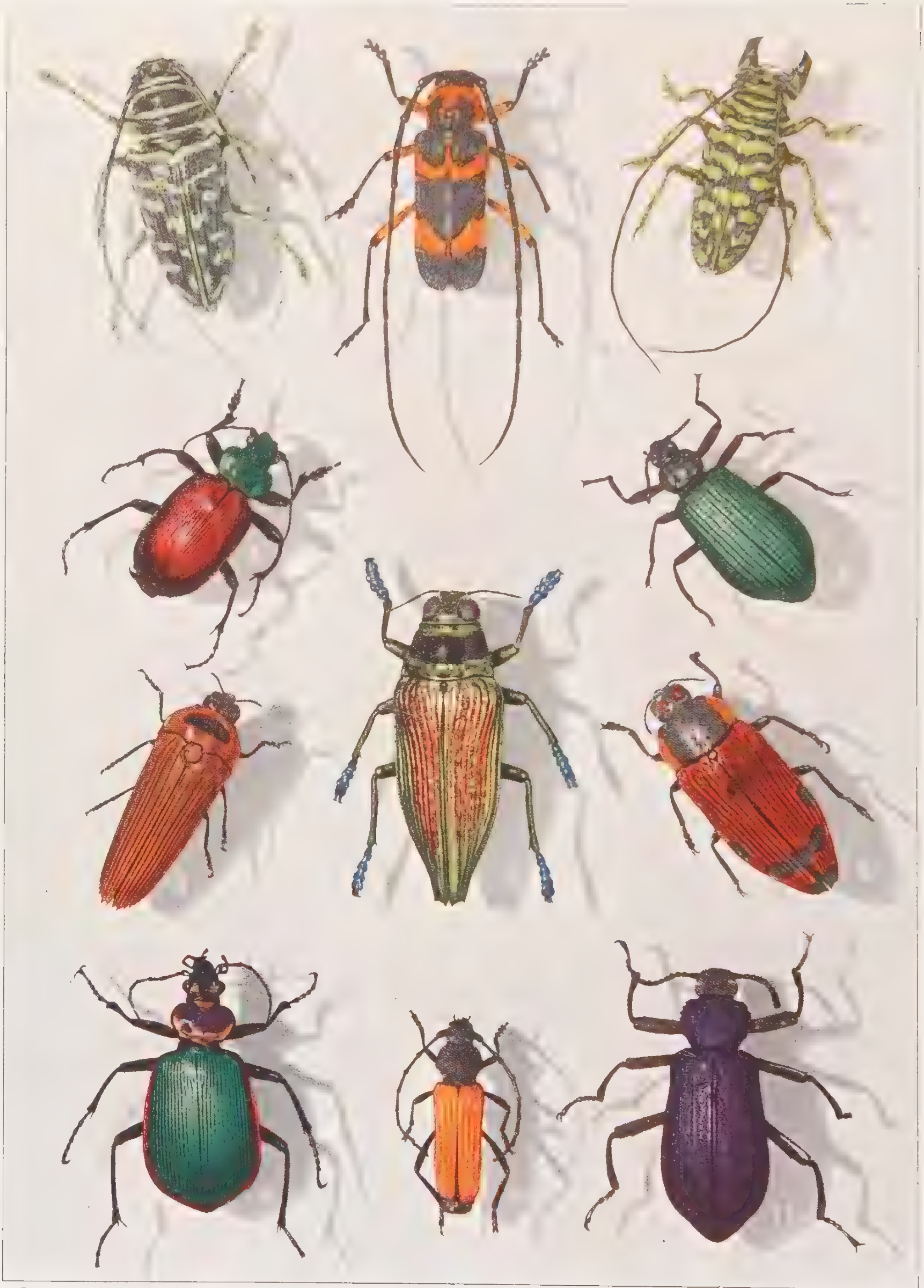
1¼ times Natural Size

BEETLES FROM MANY LANDS DISPLAY THE VERSATILITY OF THEIR ORDER

(1) *Doryphora flavozonata* Blanch.; (2) *Sagra borneoensis* Lac.; (3) *Erotylus giganteus* Linn.; (4) *Carabus auronitens* Fab.; (5) *Julodis viridipes* Cast.; (6) *Ceroglossus gloriosus* Gerst.; (7) *Tegrodera aloga* Skinn.; (8) *Zonabris oculata* Thunbg.; (9) *Dytiscus fasciventris* Say; (10) *Sagra fabricii* Lac.; (11) *Cybister fimbriolatus* Say. See text under the following Family headings: Leaf Beetle, Erotylidae Beetle, Ground-beetle, Metallic Wood-borer, Meloid Beetle, and Predaceous Diving Beetle. The Predaceous Diving Beetles and their kin are the principal foes of the larvae living at the bottom of ponds, creeks, and rivers. The Diving Beetles bear such a close resemblance to some of the diving insects of the Order *Hemiptera* that frequently they are confused with one another.



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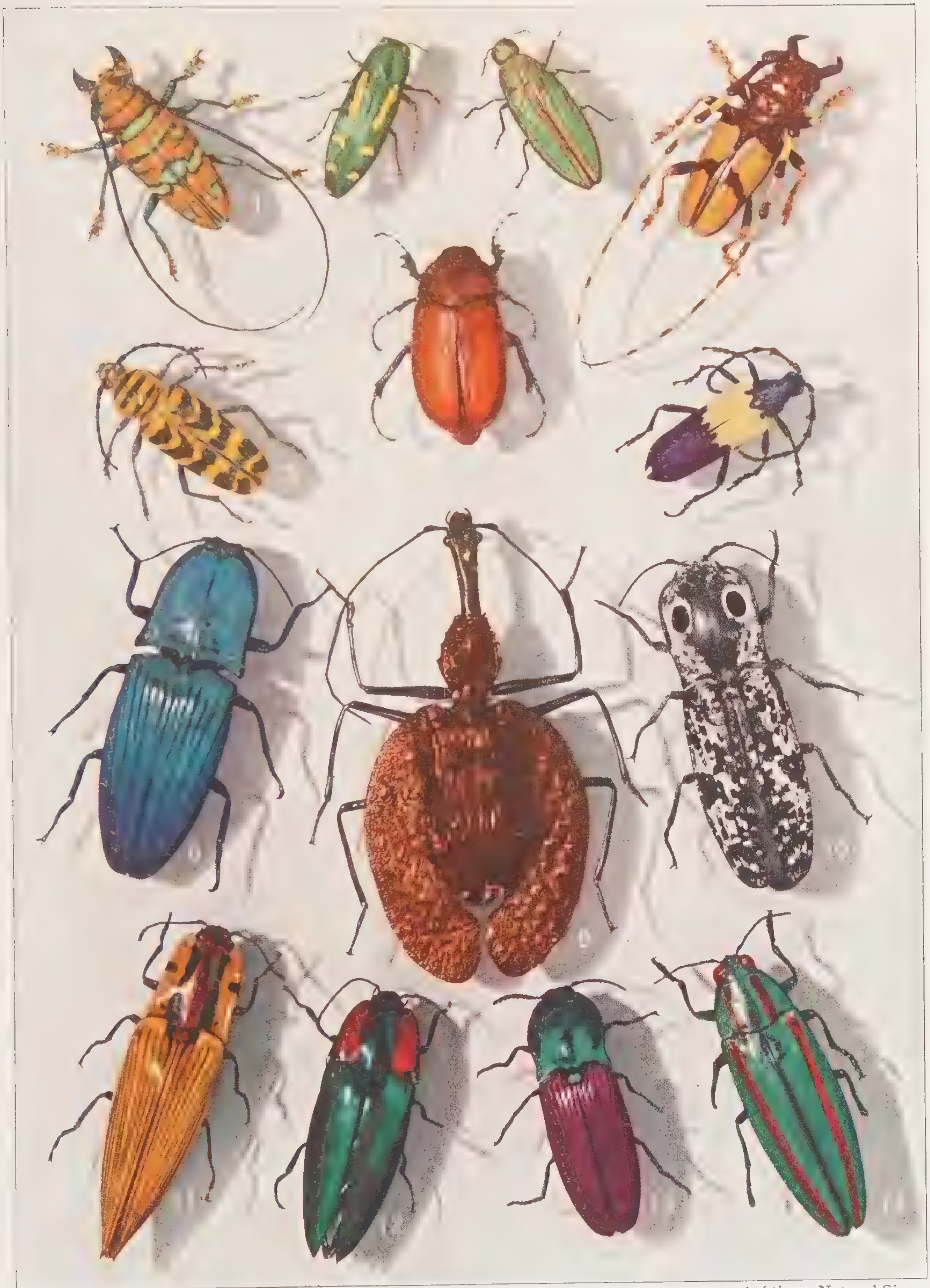
1¼ times Natural Size

A STRIKING GROUP OF WOOD BORING, GROUND-, AND DARKLING BEETLES

(1) *Sternotomis virescens* Westw.; (2) *Crioprosopus magnificus* Le Conte· (3) *Sternotomis mirabilis* Drury; (4) *Calosoma bonariense* Dej.; (5) *Metallonotus metallicus* Fab.; (6) *Hyperantha haemorrhoa* Fairm.; (7) *Psiloptera bicarinata* Thunbg.; (8) *Stigmodera variabilis* Don.; (9) *Calosoma scrutator* Fab.; (10) *Tragidion fulvipenne* Say; (11) *Odontopezus cupreus* Fab. See text under the following Family headings: Long-horned Beetle, Darkling Beetle, and Ground-beetle. Some of the long-horned beetles spend three years in their grub stage and always pupate with their heads toward the exit from their tunnels.



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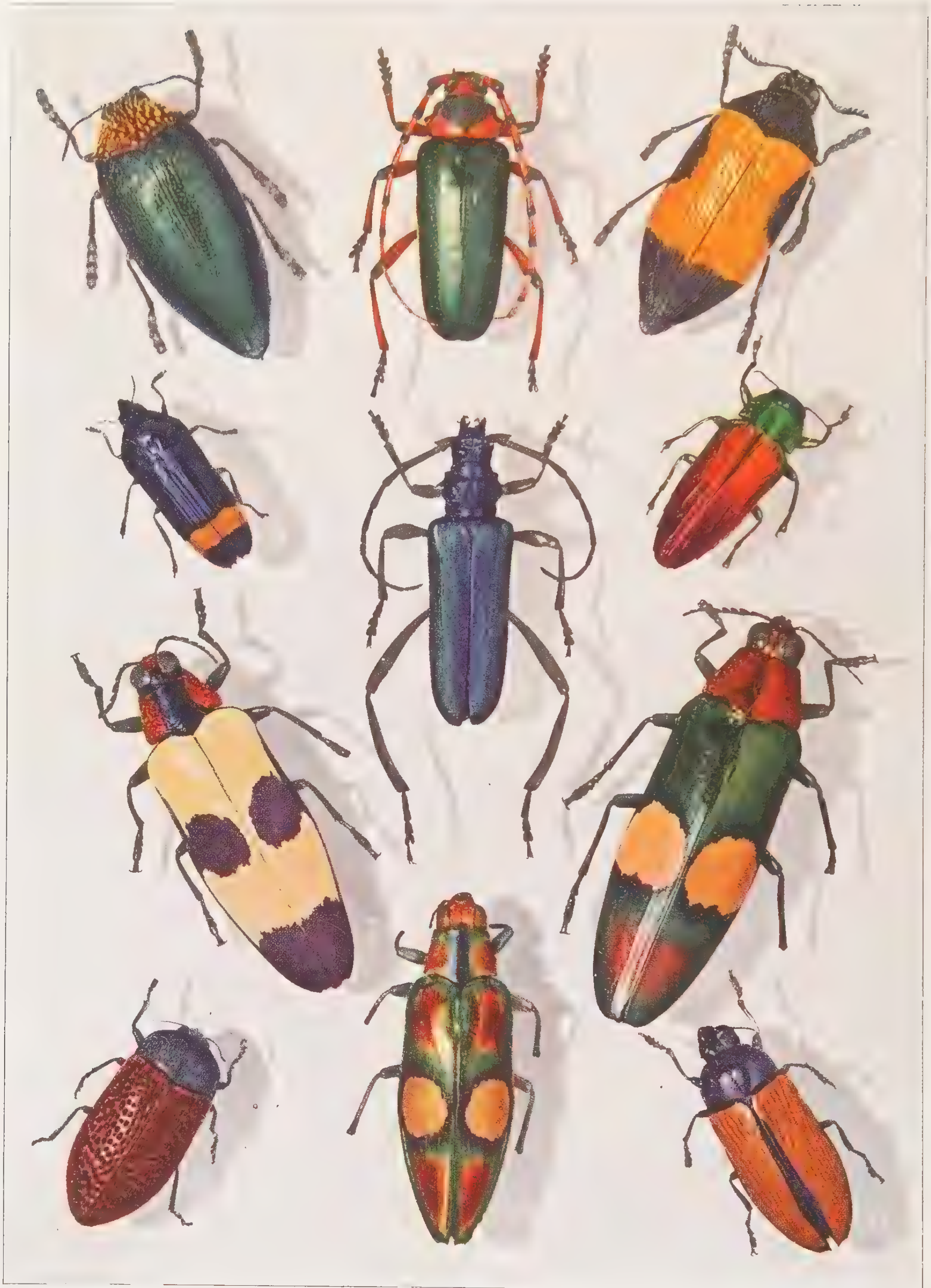
1¼ times Natural Size

SOME OF NATURE'S LITTLE JOKES ATTENDED BY A RESPLENDENT COURT

(1) *Sternotomis bifasciata* Fab.; (2) *Buprestis rufipes* Oliv.; (3) *Buprestis aurulenta* Linn.; (4) *Dendrobias reducta* Casey; (5) *Cyllene decora* Oliv.; (6) *Phyllophaga torta* Lec.; (7) *Desmocerus palliatus* Forst.; (8) *Chalcolepidius lacordairei* Cand.; (9) *Mormolyce hagenbachi* Westw.; (10) *Alaus lusciosus* Hope; (11) *Semiotus imperialis* Guer.; (12) *Campsosternus gemma* Cand.; (13) *Chalcolepidius rubripennis* Lec.; (14) *Chrysochroa fulgidissima* Schoenh. See text under the following Family headings: Long-horned Beetle, Metallic Wood-borer, Scavenger Beetle and Leaf Chafer, Ground-beetle, and Click Beetle.



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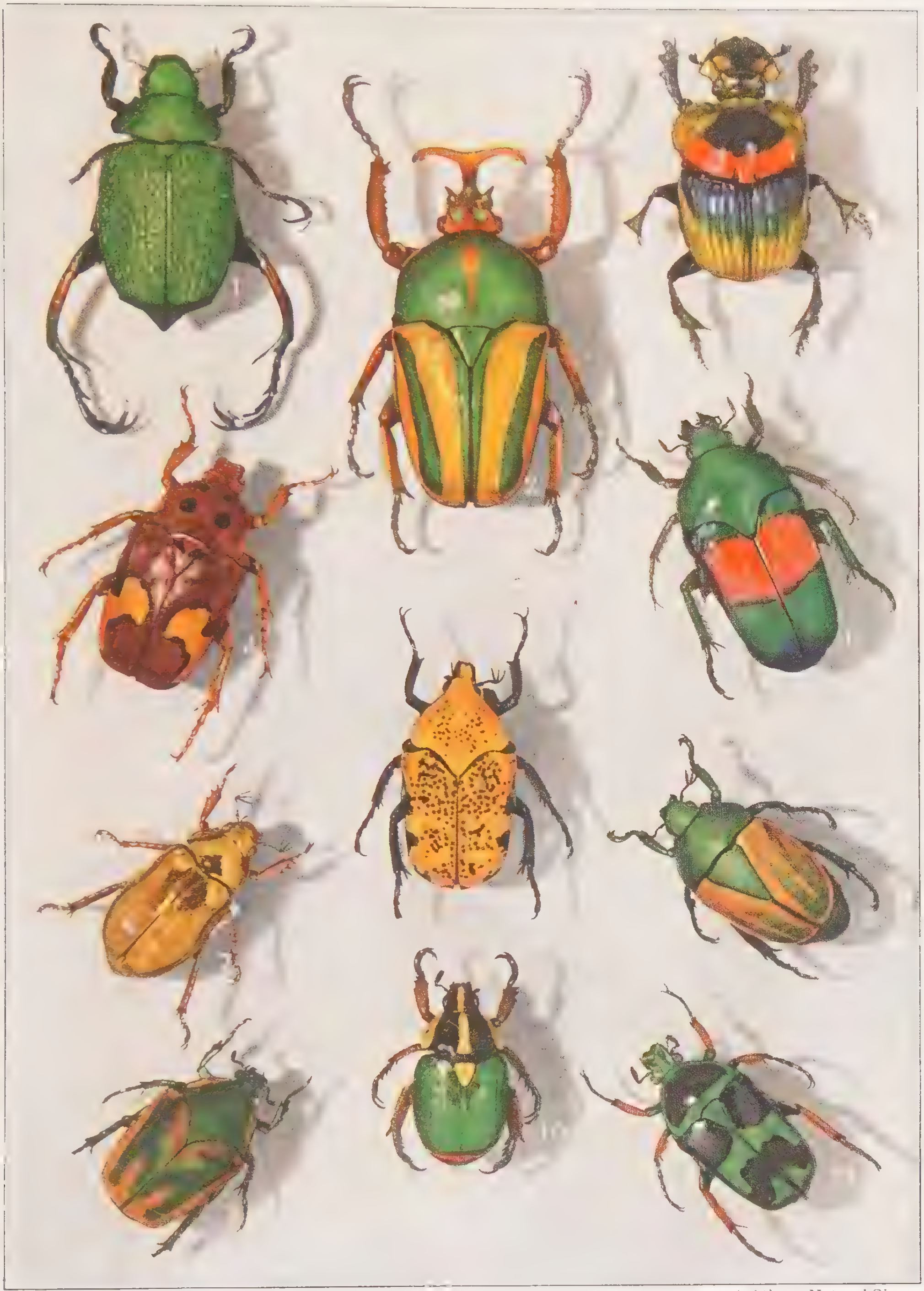
1¼ times Natural Size

FROM WHAT GOLCONDA DO THE BEETLES GET THEIR GEMLIKE GARMENTS?

(1) *Sternocera bennigseni* Kerrem [Male]; (2) *Stenaspis verticalis* Serv. [Female]; (3) *Sternocera hunteri* Waterh. [Male]; (4) *Conognatha amoena* Kirby [Female]; (5) *Callichroma schwarzi* Fisher [Female]; (6) *Belionota sumptuosa* Cast. & Gory [Male]; (7) *Chrysochroa buqueti* Gory [Female]; (8) *Chrysochroa edwardsi* Hope [Male]; (9) *Stigmodera macularia* Donovan [Male]; (10) *Chrysochroa ocellata* Fabricius [Female]; (11) *Stigmodera suturalis* Donovan [Female]. See text under the following Family headings: Metallic Wood-borer and Long-horned Beetle.



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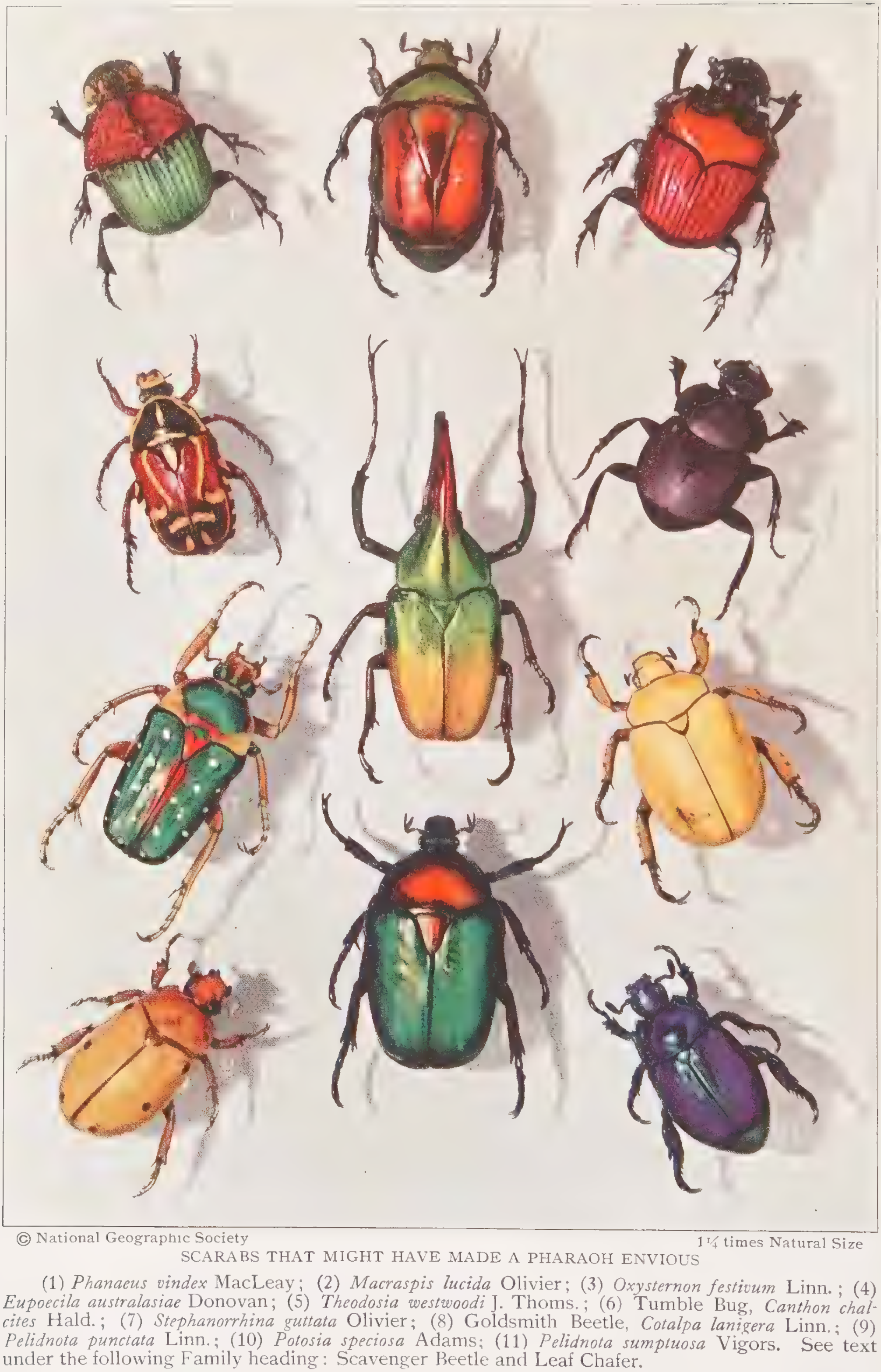
1¼ times Natural Size

DUNG BEETLES IN HABIT, BUT IN ARMOR ROYALLY CLAD

(1) *Chrysophora chrysochlora* Latr. [Male]; (2) *Eudicella morgani* White [Male]; (3) *Phanaeus imperator* Chevr.; (4) *Genyodonta flavomaculata* Fab.; (5) *Argyripa lansbergei* Salle; (6) *Ischiopsopha jamesi* Waterh.; (7) *Plusiotis resplendens* Bouc.; (8) *Macraspis pantochloris* Blanch.; (9) June Bug, *Cotinus nitida* Linn.; (10) *Rutela laeta* Weber; (11) *Heterorrhina macleayi* Kirby. See text under the following Family heading: Scavenger Beetle and Leaf Chafer.



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SCARABS THAT MIGHT HAVE MADE A PHARAOH ENVIOUS

(1) *Phanaeus vindex* MacLeay; (2) *Macraspis lucida* Olivier; (3) *Oxysternon festivum* Linn.; (4) *Eupoecila australasiae* Donovan; (5) *Theodosia westwoodi* J. Thoms.; (6) Tumble Bug, *Canthon chalcites* Hald.; (7) *Stephanorrhina guttata* Olivier; (8) Goldsmith Beetle, *Cotalpa lanigera* Linn.; (9) *Pelidnota punctata* Linn.; (10) *Potosia speciosa* Adams; (11) *Pelidnota sumptuosa* Vigors. See text under the following Family heading: Scavenger Beetle and Leaf Chafer.

The round-headed apple-tree borer is perhaps the worst pest among the Cerambycids. In its adult form, it is about three-fourths of an inch long, with two creamy stripes along its brown back from mouth to tail. It deposits its eggs on the bark at the base of the tree it exploits in June and July. These hatch in a few days and the tiny grub works its way into the soft sapwood under the bark.

After its fine chisellike mandibles get the temper of age, it begins to tunnel its way into the heart of the tree, swallowing the borings of the tunnel as it goes. Finally, after three years of eating a path through the wood, it directs its operations toward the surface.

Just before reaching the outer air, and leaving only a tiny membrane ahead of it to be ruptured when it wakes up from its transformation sleep, the grub excavates a nice little chamber, which it carefully lines with smooth, soft materials made from wood fiber, and then lies down for its change-working nap. After two or three weeks of unconsciousness, it awakens no longer a grub, but a fully accoutered long-horn.

The oak pruner has a different method of attack. It lays its egg on a tender twig. When the grub hatches, it enters the twig and feeds on its juicy fiber. As it grows, it relishes a harder diet, so it bores its way into a mature limb, which it finally cuts so thoroughly that when a high wind comes it is blown to the ground. The limb thus acts as a parachute for the grub, allowing it to reach the ground safely. It now uses the severed limb both as a food supply and a habitation. The oak pruner also attacks other trees.

Some species of Cerambycid larvæ remain in wood for surprising periods. After timber is cut and dried and used in the building of houses or the manufacture of furniture, it lacks nutritive qualities, and the growth of the wood-boring grub is so arrested that it often requires many years for the attainment of maturity. I have seen them issue from a porch column that had been standing twenty years, and recently a western college professor reported the issuance of one from the wood of a bookcase that had been in his family for nearly fifty years.

The species reproduced are: *Saperda candida* Fab. (Plate XVIII, figure 7), found in North America; *Sternotomis virescens* Westw. (Plate XX, figure 1), an African species; *Crioprosopus magnificus* LeConte. (Plate XX, figure 2), from Arizona; *Sternotomis mirabilis* Drury. (Plate XX, figure 3), found in the African Gold Coast; *Tragidion fulvipenne* Say. (Plate XX, figure 10), found in central and western United States; *Sternotomis bifasciata* Fab. (Plate XXI, figure 1), found in West Africa; *Dendrobias reducta* Casey. (Plate XXI, figure 4), habitat southern California; *Cyllene decora* Oliv. (Plate XXI, figure 5), habitat southeastern and central United States; *Desmocerus palliatus* Forst. (Plate XXI, figure 7), a native of eastern United States; *Stenaspis verticalis* Serv. (Plate XXII, figure 2), found in Texas, Arizona, and Mexico; *Callichroma schwarzi* Fisher. (Plate XXII, figure 5), found in Texas.

Tiger-beetle Family (*Cicindelidae*). The tiger-beetles are fast runners and quick flyers, and in the larval stage live up to their name, being carnivorous and voracious eaters. In that stage they are uncouth grubs, with big heads and sturdy jaws. They usually dig burrows in the ground, and lie in wait at the entrance for some unfortunate insect that chances to pass that way. In catching their prey the tiger-beetles' larvæ seize the victims with their long, sharp mandibles, and drag them to the bottom of the burrow, where they are eaten at leisure.

The larva is provided with a little hump on the fifth segment of the abdomen, on which are two strong, forward-curving hooks. These it uses to hold itself firmly in position while attacking a victim, lest the latter give a sudden jerk and pull the "bushwhacker" from its hole.

The adult beetles catch their victims and drink the blood after the fashion of a weasel. With their big eyes, long legs, sharp mandibles, and fleet movements, the tiger-beetles are identified easily.

The species reproduced is: *Cicindela scutellaris* Say. (Plate XVIII, figure 8). It ranges between Texas, Arkansas, Nebraska, and Wyoming.

Lady-bird Beetle Family (*Coccinellidae*). Perhaps no beetle clan surpasses the lady-birds as friends of man. Their pretty polka-dot wing cases and their gentle demeanor are in keeping with their beneficent relation to man. But to certain of our insect foes the larvæ of this family are veritable roaring lions and stalking tigers going about seeking whom they may devour. Plant-lice, scale insects, and many others of the "wee beasties" of insectdom the lady-birds destroy by the billions.

The larvæ are more active than beetle grubs usually are, running about on plants in search of game. They ordinarily "change their clothes" three times before reaching maturity, sometimes changing their color in doing so. They spend four or five weeks in the larval stage; the eggs are laid on the bark, stems, and leaves of the trees or plants they visit, and hatch in a few days.

There are about 2,000 known species of lady-birds in the world, of which about 150 species are natives of America. Some have the curious habit of congregating in great masses on mountain tops, to spend the winter, once they have gotten their wings. California fruit growers collect them, and put them in cold storage where they are retained until they are needed for keeping down plant-lice the following summer (see illustration, page 9).

The species reproduced is: *Epilachna borealis* Fab. (Plate XVIII, figure 10), which ranges over North America and Mexico.

Scavenger Beetle and Leaf Chafer Family (*Scarabaeidae*). The Scarabaeid family has two branches, well differentiated by their habits—the scavengers, of which the tumble bug or dung beetle is typical; and the leaf chafers, of which the rose bug or rose chafer is a representative species.

There are about 13,000 known species of Scarabaeids, of which about 5,000 belong to the dung beetle branch of the family.

The ancient Egyptians, observing the beetle's habit of rolling around pills of dung and dirt, are supposed to have interpreted this practice as a typification of the planetary and lunar revolutions, and therefore held that its disappearance and return was emblematic of eternal life (see, also, illustration, page 44).

The leaf chafers constitute the more numerous branch of the Scarabaeid family. In size, the species range from the big June bug or May beetle, down to the small rose chafer or rose bug. The larvæ of the iridescent May beetle are big fat grubs found in lawns, fields, and gardens. They spend three years in their journey from the egg to the possession of wings. In the fall they dig below the frost line, and in the spring come up again to spend the summer feeding on the tiny roots of vegetation.

The rose chafer larvæ seem to thrive best in sandy ground. Observers have noted that in regions where there is a strip of land underlaid with a clay subsoil, bordered by another strip in which there is a sandy subsoil, very few rose chafers appear until the wind blows from the sandy subsoil region. They then come in hosts to the land underlaid with clay.

A newly imported member of the Scarabaeid family is the destructive green Japanese beetle, which a few years ago gained a foothold above Philadelphia on the Jersey side of the Delaware River.

The species reproduced are: *Macrodactylus angustatus* Beauv. (Plate XVIII, figure 11), found in North America; *Popillia japonica* Newman. (Plate XVIII, figure 13), introduced into the United States from Japan; *Phyllophaga torta* Lec. (Plate XXI, figure 6), found in North America; *Chrysophora chrysochlora* Latr. (Plate XXIII, figure 1), found in Ecuador and Peru; *Eudicella morgani* White. (Plate XXIII, figure 2), native of West Africa; *Phanaeus imperator* Chevr. (Plate XXIII, figure 3), habitat South America; *Genyodonta flavomaculata* Fab. (Plate XXIII, figure 4), found in Africa; *Argyripa lansbergei* Salle. (Plate XXIII, figure 5), habitat Brazil; *Ischiopsopha jamesi* Waterh. (Plate XXIII, figure 6), a species from British New Guinea; *Plusiotis resplendens* Bouc. (Plate XXIII, figure 7), a native of Costa Rica; *Macraspis pantochloris* Blanch. (Plate XXIII, figure 8), found in South America; June Bug (*Cotinus nitida* Linn. Plate XXIII, figure 9), a native of eastern and southern United States; *Rutela lacta* Weber. (Plate XXIII, figure 10), found in northern South America; *Heterorrhina macleayi* Kirby. (Plate XXIII, figure 11), a native of Central America; *Phanaeus vindex* MacLeay. (Plate XXIV, figure 1), found in eastern United States; *Macraspis lucida* Olivier. (Plate XXIV, figure 2), found in Central and South America; *Oxysternon festivum* Linn. (Plate XXIV, figure 3), South American species; *Eupoecila australasiae* Donovan. (Plate XXIV, figure 4), native of Australia; *Theodosia westwoodi* J. Thoms. (Plate XXIV, figure 5), habitat Borneo; Tumble Bug (*Canthon chalcites* Hald. Plate XXIV, figure 6), a native of North America; *Stephanorrhina guttata* Olivier. (Plate XXIV, figure 7), found in West Africa; Goldsmith Beetle (*Cotalpa lanigera* Linn. Plate XXIV, figure 8), found in eastern United States; *Pelidnota punctata* Linn. (Plate XXIV, figure 9), familiar species in eastern United States; *Potosia speciosa* Adams. (Plate XXIV, figure 10), habitat southwestern Asia; *Pelidnota sumptuosa* Vigors. (Plate XXIV, figure 11), found in South America.

Snout Beetle Family (*Otiorhynchidae*). This family is represented in our fauna by more than 200 species. It includes Fuller's rose beetle, the strawberry crown girdler, and the black vine weevil. Many of its members are notorious as greenhouse pests.

The species reproduced are: *Cyphus 16-punctata* Linn. (Plate XVIII, figure 12), found in South America; *Hypomeces squamosus* Fab. (Plate XVIII, figure 14), found in India.

Erotylidae Family. This is a small family which resembles click beetles in form, and whose larvæ bore into the stalks of clover. The larvæ of some species feed on fungi.

The species reproduced is: *Erotylus giganteus* Linn. (Plate XIX, figure 3), which occurs in Cayenne, French Guiana.

Carabid Beetle Family (*Carabidae*). The 1,200 species of this group of beetles contain many interesting insects. One of these is the bombardier beetle which, when pursued or attacked by an enemy, fires at the foe a tiny puff of acrid, reddish "smoke," with a popgun report. Comstock has found that the bombardier is able to use four or five rounds of ammunition without exhausting its supply.

One species belonging to the Carabid family is known as *Calosoma scrutator*, the latter part of its name being derived from its habit of scrutinizing everything in its search for caterpillars. It and its close cousins are popularly known as caterpillar hunters. One species has been brought to America from Europe to help wage war on the brown-tail moth. Some of the Calosomas are aggressive foes of the hairy tent-caterpillar that is such an enemy of the orchardist and landscape gardener.

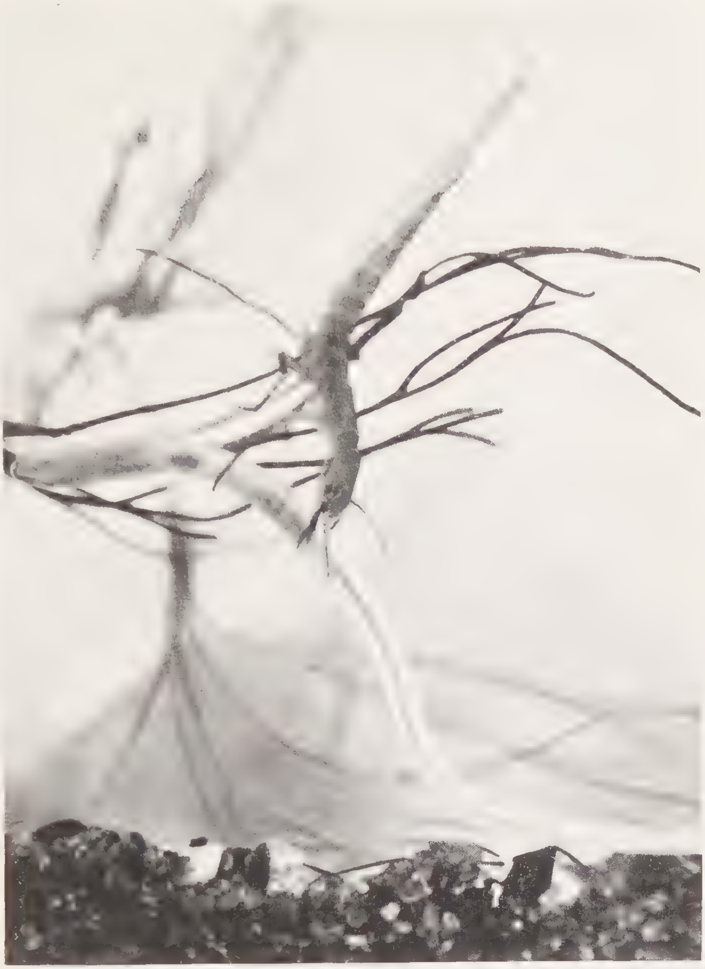
Other Carabids eat the larvæ of codling moths and of the plum curculio. Some species here and elsewhere dwell in caves, and are sightless. Other species dwell in moist, damp places where snails may be found, and have their palpi shaped like long-handled spoons suitable for drawing snails out of their shells.

The species illustrated are: *Carabus auronitens* Fab. (Plate XIX, figure 4), a native of Central Europe; *Ceroglossus gloriosus* Gerst. (Plate XIX, figure 6), found in Chile; *Calosoma bonariense* Dej. (Plate XX, figure 4), found in Brazil and Argentina; *Calosoma scrutator* Fab. (Plate XX, figure 9), a North American species; *Mormolyce hagenbachi* Westw. (Plate XXI, figure 9), a native of Sumatra.

Predaceous Diving Beetle Family (*Dytiscidae*). There are some 300 species of this family of predaceous carnivorous diving beetles in America. They get their name of water-tigers from the persistent manner in which their larvæ search for living food. Research indicates that the adults hibernate in mud, under water. It is believed that the water-tigers were once dry-land dwellers.

Nagel states that the water-tigers secrete a digestive fluid which they inject into the body of their victims, turning the latter's flesh to broth. On this they sup at their pleasure. The mature beetles live for a long time, one entomologist having kept a *Dytiscus* three and a half years in perfect health in a glass vessel filled with water. He fed it bits of raw meat.

The species reproduced are: *Dytiscus fasciventris* Say. (Plate XIX, figure 9), and *Cybister fimbriolatus* Say. (Plate XIX, figure 11), both found in North America.



Photograph by Paul Griswold Howes

A LARVAL WATER-TIGER FEEDING ON A YOUNG EEL

The insect fastened its jaws in the flesh of the eel and swam with great effort to a higher perch in the aquarium. Here it sucked the body juices of the victim until it became white. The water-tigers are among the most ferocious of all the insects.

Darkling Beetle Family (*Tenebrionidae*). These insects occur chiefly in dry and warm regions. Most of the American species, of which there are more than 400, occur in the southern section of the United States. The family includes the *Tenebrio* meal-worm, the forked fungus beetle, and the pinacate bugs. The latter defend themselves when disturbed by elevating the hind part of the body and discharging an oily fluid. After being attacked they walk off clumsily, presenting an absurd appearance with the end of the body held as high as possible.

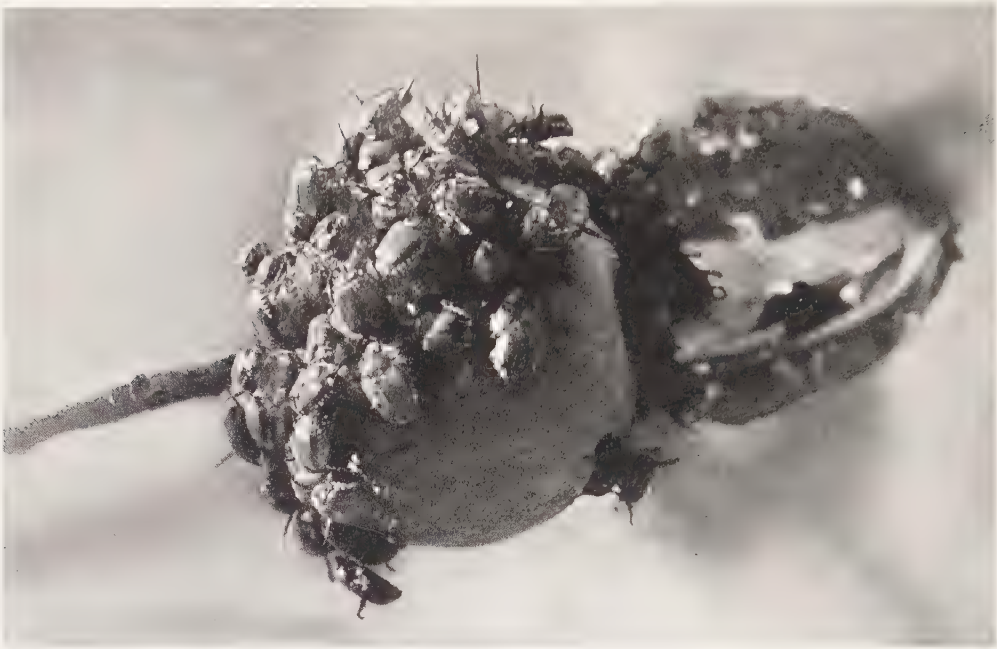
The species reproduced are: *Metallonotus metallicus* Fab. (Plate XX, figure 5), and *Odontopezus cupreus* Fab. (Plate XX, figure 11), found in Africa.

Click Beetle Family (*Elateridae*). The click beetles form a most interesting and cosmopolitan family. There are about 7,000 known species, of which some 350 are found in North America.

The larvæ of the click beetles are the familiar wire-worms which often do so much damage to crops just beginning to grow. Corn, meadow grass, wheat, and other cereals suffer severely from the periodic invasion of the wire-worms. The beetles fly about the fields in the late spring, depositing their eggs in plowed or grassy ground.

In Cuba there are phosphorescent species which emit a strong greenish light. Many women keep them alive in little lace pockets, or fastened to delicate golden chains.

The species reproduced are: *Chalcolepidius lacordairei* Cand. (Plate XXI, figure 8), found in Mexico and Nicaragua; *Alaus lusciosus* Hope. (Plate XXI, figure 10), found in Mexico and southwestern United States; *Semiotus imperialis* Guer. (Plate XXI, figure 11), a native of South America, especially Colombia, Venezuela, and Peru; *Campsosternus gemma* Cand. (Plate XXI, figure 12), a native of China; *Chalcolepidius rubripennis* Lec. (Plate XXI, figure 13), a native of Lower California and Honduras.



JAPANESE BEETLES DINE ON A PEACH

At the beginning of the season the beetles attack the fruits prematurely ripening because of infestation by other foes, but later they turn their attention to the sound peaches, apples, etc. As many as 278 beetles have been removed from a single fruit.

Photographs courtesy U. S. Department of Agriculture

JAPANESE BEETLES COLLECTED BY BOYS AT RIVERTON, NEW JERSEY

In 1916 only a few beetles could be collected by one person in a single day. By 1919 they had become so thick that one person could collect as many as 20,000 in 12 hours. During a recent season an average of one and one-third gallons of beetles were shaken from each of 156 ten-year-old peach trees, all of which seemed as full as ever 24 hours later. An average of 175 larvæ were found in each square yard of a New Jersey pasture.

COLLECTORS OF PARASITIZED JAPANESE BEETLES AT SAPPORO, JAPAN

Scores of women and children of Japan have been enlisted in the work of gathering proved parasites of the Japanese beetle to send to the United States and help us destroy the beetle by this means.

Photographs courtesy U. S. Department of Agriculture

ARMIES OF ALLIES BEING SHIPPED FROM KOIWAI, JAPAN, TO RIVERTON, NEW JERSEY

Nearly 8,000 parasitized grubs of the Japanese beetle are contained in the boxes of this shipment. The parasites belong to the Scoliid wasp family. While man probably will continue to resort to mechanical warfare in holding the Japanese beetle in check, the major offensive is being conducted by insect allies imported from Japan, including three species of the Tachina fly family (see text, page 67), two species of the Dexiid fly family (see text, page 70), four species of the Scoliid wasp family (see text, page 52), and one species of the Carabid beetle family (see text, page 86).

Photograph courtesy U. S. Department of Agriculture

PREPARING TO RAISE AN ARMY OF ALLIES TO FIGHT JAPANESE BEETLES

These workers in the Moorestown, New Jersey, laboratory of the United States Bureau of Entomology are unpacking material just received from Japan. The shipment contains eggs of a little Tachina fly (see text, page 52) which preys on Japanese beetles in the land of the Mikado. It is hoped that the flies from these eggs will slaughter millions of beetles.

The natural-color illustrations of 263 insects in this number of the NATIONAL GEOGRAPHIC MAGAZINE are the result of more than three years of research, selection, and experimentation by the illustrations division of The Magazine.

The specimens pictured represent most of the insect families to be found in North America. They were selected from the U. S. National Museum's collection of more than a million individuals through the generous coöperation of the experts of the Museum and of the Bureau of Entomology of the U. S. Department of Agriculture.

Each specimen reproduced on the 24 full-page color plates was chosen as the most picturesque and colorful representative of its species or family. The subjects selected were placed with care in relaxing jars (a sort of humidor) to render flexible their delicate legs, wings, and antennæ, so that they might be "posed" in lifelike attitudes. After the humidor treatment, the individuals were grouped according to their scientific relation one to another, and each group was then skillfully arranged for symmetry and with appreciation of color contrasts.

The minuteness of some of the specimens, their irreplaceable value in the Museum's collection, and the fragile nature of their many anatomical members added materially to the sense of responsibility of the members of the National Geographic Society's illustrations staff and to the time required in obtaining the desired results.

The 21 color plates of specimens, on each of which is reproduced from 6 to 21 individual insects, were arranged and photographed by Mr. Edwin L. Wisherd, of The Society's photographic staff.

Supplementing the photographic records of the actual specimens are the three paintings showing the life history of three representative insect families—the Caddisfly (Plate I), the Bumble-bee (Plate IX), and the Japanese Beetle (Plate XVII). These have been executed in microscopic detail by The Society's naturalist-artist, Mr. Hashime Murayama.

FRANKLIN L. FISHER.

OUR FRIEND THE FROG

By Doris M Cochran

in the peaceful mission of surveying a canal whose construction would mean more to his country than anything else that could happen to it. But because of our isolation and the distance of the canal zone from his favorite haunts, or perhaps because he knew we were prepared, no attempt was made to molest us.

We had little fear of a surprise after we had been in the country for a few months, for our doctors had made us many friends, who would have warned us of any threatened attack. Natives made long trips, taking two or three days by canoe, to our jungle camps to see the *médicos*. To their minds, our doctors could perform miracles.

To see a child so weak from amœbic dysentery that it could not walk, but had to be carried by its parent from the canoe to the camp, cured in a few days, so that it could run around naturally, or to see badly infected wounds and sores improve rapidly under proper treatment, or to see a minor operation performed which cured some trouble that had existed for years, was truly a miracle to these sufferers.

Several victims of snake bite were brought in to our camps near Greytown. The patient was always wrapped in sheets from head to foot, for it is a local superstition that if he looks upon a woman who is soon to become a mother he will die, and if she looks at him her child will be born dead.

Grown men deaf or blind since childhood, permanent cripples, or old people in the last stages of leprosy or cancer had to be turned away, but the number of those who could be helped far outnumbered those with incurable ills.

NICARAGUA'S EARLY CIVILIZATION RELATED TO AZTEC CULTURE

The early Indian civilization found in Nicaragua by the Conquistadores was closely related to the Aztec civilization of Mexico. In their writings the early Spanish invaders make frequent reference to the reverence with which the Indians spoke of Montezuma. There was a similarity of religion, language, and customs that indicated close contact with the more advanced civilizations of the north.

We visited Zapatera Island to see the idols and ruined places of worship of these early races (see illustrations, pages 623, 624, and 626).

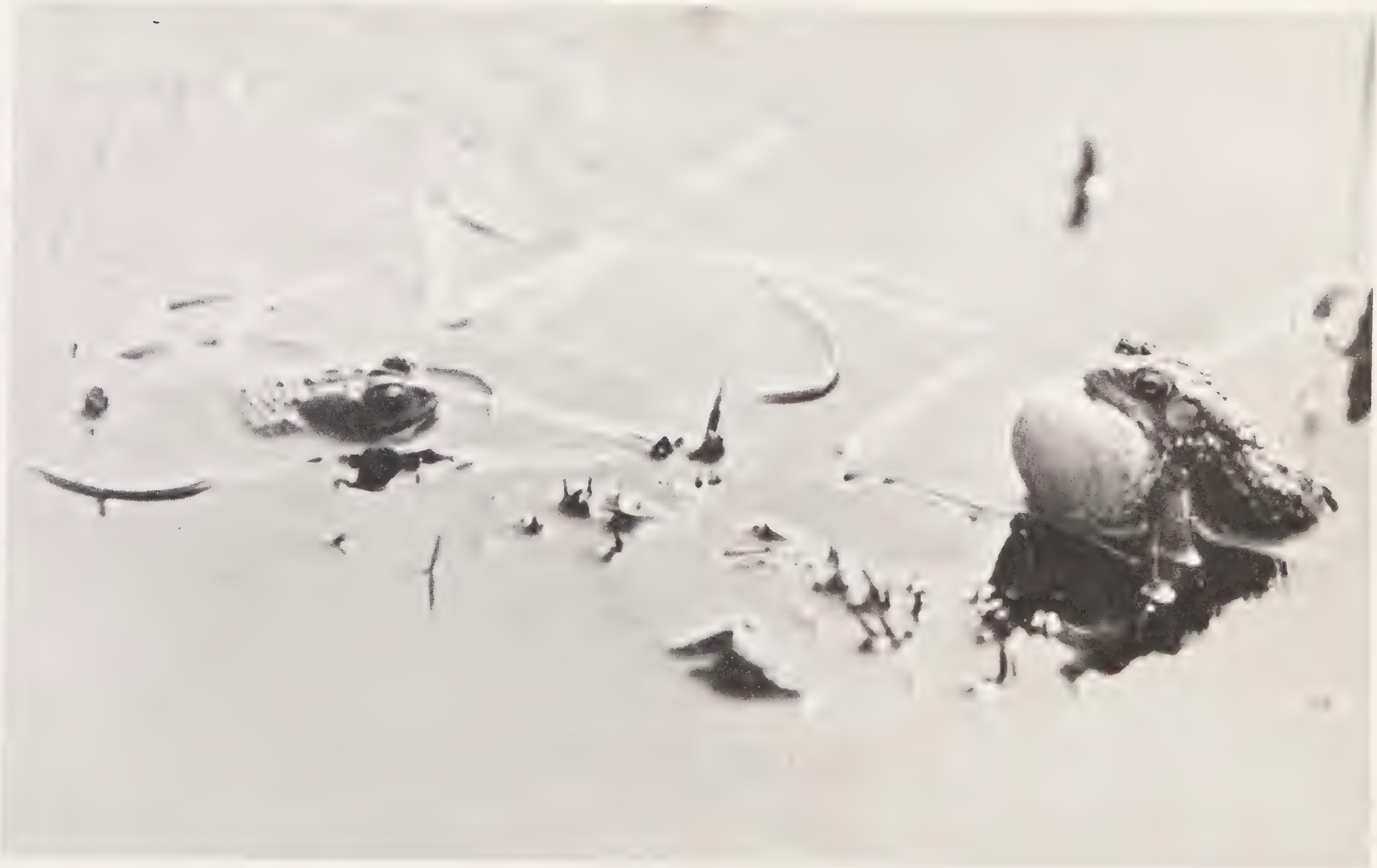
Zapatera is the cone of an extinct volcano long since overrun with a dense growth of tropical vegetation which has converted a gigantic heap of ashes and molten lava into a garden of fertile soil. Except for a few coffee groves high up on the slopes of the extinct volcano, there are no signs of civilization, as only a few native fishermen live along the shore. Most of the idols are concentrated on a plateau several hundred feet above the lake and overlooking Mombacho.

Of equal interest is a small island near Zapatera, which we visited on our return trip to Granada. It is called Isla de los Muertos (Island of the Dead) by the natives and is uninhabited. The more daring natives will land on the island in the daytime, but staying overnight is another matter.

We made numerous friends in Nicaragua and left the country with many regrets. We hope to return with steam shovels and dredges to dig a new interoceanic canal, but we are happy to have known Nicaragua and the Nicaraguans with all their charm of to-day, untouched by the bustling outside world.

Few tourists have as yet found the way to Nicaragua. Yet its wonderful scenery—with broad plains, magnificent mountains, turbulent rivers, and tropical grandeur—and, above all, its soft-voiced people, provide sources of never-failing charm and interest. From the very railroad stations you can step into streets and into houses that have remained practically unchanged for centuries.

Notice of change of address of your NATIONAL GEOGRAPHIC MAGAZINE *should be received in the office of the National Geographic Society by the first of the month to affect the following month's issue. For instance, if you desire the address changed for your July number, The Society should be notified of your new address not later than June first.*



© Lynwood M. Chace

THIS UNUSUAL PICTURE SHOWS THE AMERICAN TOAD (BUFO AMERICANUS) TRILLING HIS EVENING SONG

The male toad sits in a puddle and with throat puffed out serenades his lady. Every trill gives a thrill, no doubt. During the call the mouth and nostrils are closed while the air is driven back and forth between lungs and mouth. Some of the air escapes into the balloonlike resonating organ, which immediately fills up and often extends in front of the head (see page 629).

OUR FRIEND THE FROG

By Doris M. Cochran

Assistant Curator, Division of Reptiles and Amphibians, U. S. National Museum

SPRINGTIME is here again, heralded by delicious odors of early blossoms, green mists of soft young leaves throughout the woodland, the warm touch of the sun, the echoing voices of birds. Of birds, did you say? That high-pitched, thrilling chorus coming from yonder ravine, and seeming to express the vibrant joy of all living things at the return of the glorious season of growth, is not included in any known category of bird notes.

If you would look upon the creatures from which these joyously ear-splitting calls emanate, come with me for a few paces and you may see them for yourself.

Approaching the ravine, we find at the bottom of it a marshy place centered about a little pool, the banks of which are still covered with the brown fallen leaves of last year. We can hear the chorus going at full blast and becoming louder with every step we take, but as yet we discern nothing. Surely these must be very large creatures to make such a din!

Now we are within a few yards of the pool. Suddenly the chorus ceases, and almost at our feet some small brown fragments of the forest floor detach themselves and make flying leaps into the shallow waters of the pool, and we see that they are tiny cricket-frogs! (See Color Plate III.)

Our curiosity is now thoroughly aroused and we make our way cautiously to a tussock of grass overlooking the water, being careful not to tread on any of the little lumps that we suspect may turn into minute froglets without warning. But we might have spared our pains, for all the frogs on our side of the pond have followed their leader into the water.

There they are, just a few inches from the shore, staring up with their widely opened, protruding eyes, and not even taking the trouble to hide under the leaves of water plants dotting the surface here and there.

A FROG'S MEMORY IS SHORT

We remain quiet for a moment, and so do the frogs. But a frog's memory is short, and by standing perfectly motionless we are soon forgotten. One bold little fellow swims to the bank and hauls himself out onto a flat stone, and his companions are not slow to follow.

As we watch, we see the nearest frog puffing out his yellow throat, and while we anxiously wonder if he is choking to death, he utters a staccato note, which he repeats at intervals of a second or two, while his throat expands for each effort. Now two or three more join in, and presently the whole chorus is in full tilt, with a hundred or more participants on the bank, each with his little throat bubbling madly up and down with his vocalistic enthusiasm (see pages 628, 649).

The chorus appears to have at times a kind of rhythm, destroyed often by a small group that seems to have got out of time with the music, and restored once more by the efforts of the majority, only to be lost again by some small nonconformist. Heard close by, the note of an individual frog loses some of its musical quality and sounds more like the spasmodic winding of a watch or the irregular shaking of castanets.

THE FEMALE FROG NEVER SINGS

Now that we have grown accustomed to the song, we pay more attention to the appearance of the singers. We note their color, which ranges from a dull brown on some individuals through all shades of olive-gray to bronzy green, with usually some irregular darker bars across the hind legs and a conspicuous green X-mark between the shoulders.

The skin of the back is slightly roughened, this condition being caused by the numerous glands found, more or less, in the skin of all amphibians, which serve to secrete the acrid slime that makes some species so distasteful to their enemies.

Some of the frogs do not take part in the song, but sit placidly on the floating leaves moored to the shore. These are the females, which never sing. They average slightly larger than the males, achieving the dimensions of one and one-quarter inches in length. Their throats are white and smooth. The males have yellow throats

Photograph by Lynwood M. Chace

THE WINNING SMILE AND OGLING EYE

This amphibian swain seems to know just how to win his lady fair, judging from his knowing facial expression. Note reflection of kneeling cameraman in pupil of right eye, while in the other a miniature landscape may be seen.

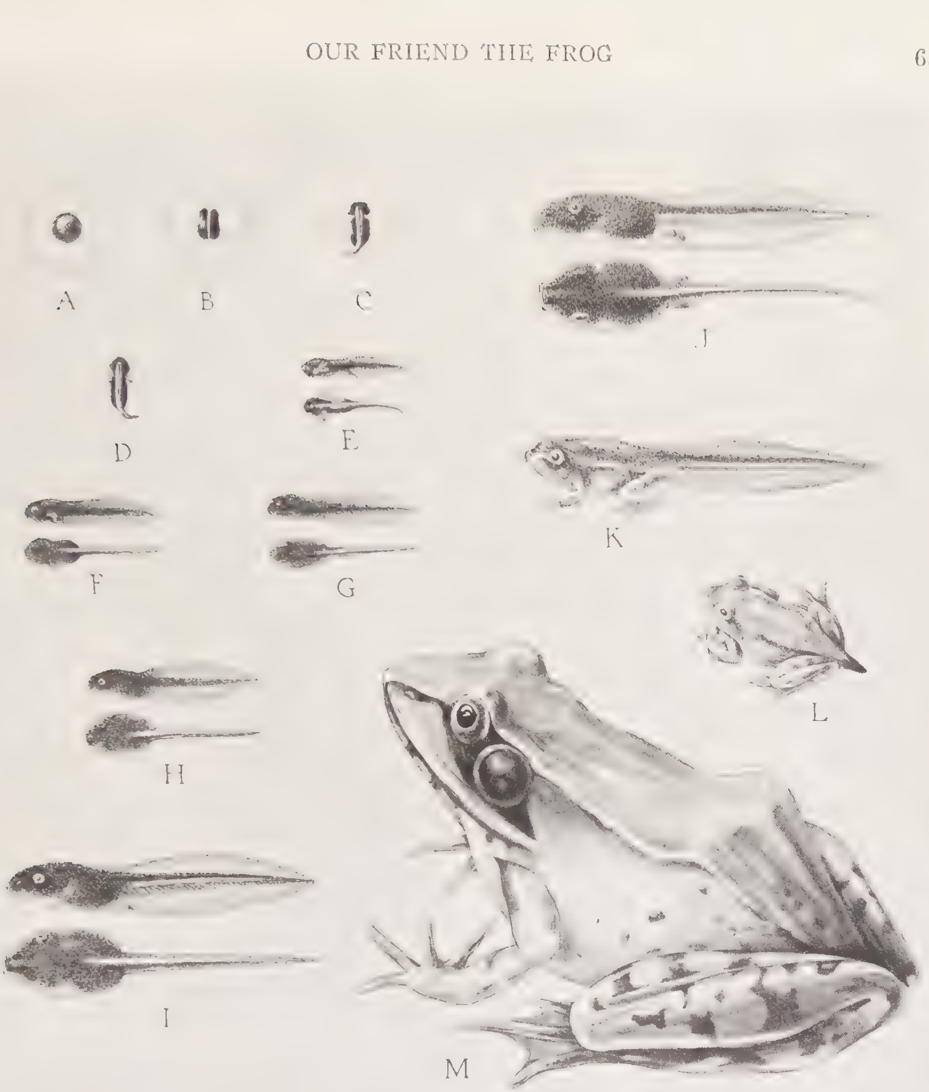
clouded with gray markings, and when the call is not being given, the loose gular skin lies in folds.

The females do not occupy themselves continuously in listening to the chorus in which they cannot participate. A low-flying aquatic insect is hovering over the surface of the pool, and finally comes near to one of our beady-eyed, attentive frogs. There is a well-directed leap, a little splash as the frog lands in the shallow water, and the insect has disappeared. No, not quite, for there is still the tip of a shiny wing protruding from the corner of the frog's mouth. As we watch, the frog bats its eyes, gulps hard, and even this vestige is gone!

THE FROG CAN SEE INSECTS ONLY IN MOTION

When engaged in seeking food, the frog is interested only in prey which is moving. If an insect remains motionless, it becomes invisible to the frog, who stays with his eyes attentively staring straight at it, but makes no effort to take the luscious tidbit which may be at the very end of his nose. But if the insect begins to move, froggie becomes instantly animated, and usually one well-directed leap rings down the curtain for the insect.

Food is never so interesting to a frog as when there is a chance of its going down the other fellow's throat. To watch two frogs intent upon stalking one insect is to observe one of Nature's little comedies of manners. Even after the food has been snapped up by one frog, the other often makes several vain efforts to seize it by a fast-vanishing wing or leg, the successful captor often having to aid his prize to its destination by using his hands to shove the more difficult portions into his wide mouth. The process of swallowing, once the insect has been successfully stored inside, involves the closing of the eyes and the low-



Drawing by Hashime Murayama

THE LIFE HISTORY OF THE FROG

The development of the wood-frog, *Rana sylvatica* (Plate III), is outlined here in various stages, from the egg to the fully adult form: (A) first day, (B) second day, (C) fourth day, (D) fifth day, (E) eighth day, (F) tenth day, (G) twelfth day, (H) fourteenth day, (I) third week, (J) seventh week, (K) beginning of ninth week, (L) eleventh week, (M) third year. One and one-half times natural size. In the preparation of this drawing and the paintings from life (pages 635-642) the National Geographic Society is indebted to Dr. William M. Mann, Director of the National Zoölogical Park, for helpful coöperation.

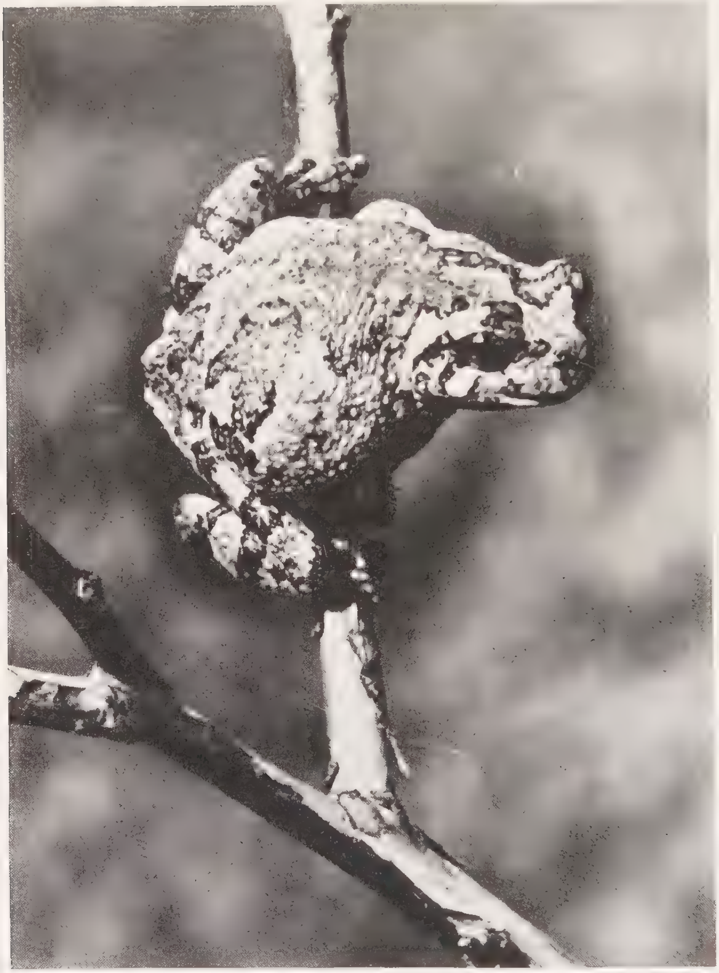
ering of the eyeballs, which serves to start the food down the broad gullet.

The tongue is attached to the front of the lower jaw, and when the mouth is closed it lies flat and points backward down the throat.

In seizing a fly, the tongue unfolds and projects out of the mouth, its attachment at the front allowing the use of its full length. Like a trap covered with glue, it is coated with a viscous, sticky substance which helps to snare the insect.

OUR FRIEND IS AFRAID OF DEEP WATER

Should our frog friend happen to land in deep water after his fly-catching leap, which is not by any means always successful, he will swim frenziedly toward shore. He has an innate fear of deep waters, in which live all manner of frog-eaters—



Photograph by Lynwood M. Chace

"TREE-TOAD UP A TREE": NATURAL SIZE

When clinging to the trunk of a tree the tree-toad (*Hyla versicolor*), whose song in spring is so familiar, blends so well with the bark that he is hardly visible, but accidentally touch his soft, yielding body and you will know he is there. Each toe is provided with an adhesive disk (see text below).

voracious fish, turtles with their sharp, cruel, tearing jaws, crayfish, and other enemies. The cricket-frog can swim well, however, and his hind feet have short webs stretched between the five toes for this purpose. The front feet, having four fingers only, are not webbed and are not used in swimming.

We notice that small round disks are to be seen at the tip of finger and toe, and this tells us that our frog is more terrestrial than aquatic, and that he belongs to the family Hylidæ, called tree-toads or tree-frogs, of which all the members are characterized, among other things, by the possession of disked toes, and consequently they all have some ability in climbing (see Color Plates I, II, and III).

The shallow water of the little pond, only a few inches in depth, has been slightly warmed by the rays of the April sun, and this warmth of air and water, together with the abundant rains, has induced the early mating of the cricket-frogs.

Attached to the submerged stems of sedges near the shore, we see some globular, translucent objects, each with a round black center, while on the sand and leaves in the shallows there are more like them scattered at random. These are the eggs of the cricket-frogs, laid the night before by one of the newly mated females, and already well along in their developmental stages.

A female may lay as many as 240 eggs, which are fertilized externally by the male, who grasps the female in an axillary embrace.

The eggs are deposited, usually singly, but sometimes in small masses, on water plants or on sticks or leaves lying in shallow water. An egg consists of the yolk—the round black center—and the vitelline envelope—the surrounding transparent membrane—which begins to absorb water as soon as the egg is laid, and thus immediately swells to be several times its original size and forms a moist cushion of protection to the egg.

But already danger besets the germ of life growing there. A gray fungus or mold,

© Lynwood M. Chace

A LITTLE GAME OF LEAPFROG

The big toad is one of the least belligerent of creatures and does not resent being used as a footstool by the young tree-toad who sits on his head. A repetition of this tableau may well take place in the vivarium, where the frogs tend to "stack up" on top of each other.

Saprolegnia, may penetrate the vitelline envelope, sprout upon the yolk, and thus cut off the life of the little frog before it has well begun. But if Fate is kind and conditions are favorable, the central yolk, at first a single cell, begins at once to grow, dividing into two cells, these into four, these into eight, and so on in the typical way (see, also, page 631).

TADPOLES HATCH ON THE FOURTH DAY

Under favorable conditions, the tadpole hatches on the fourth day. At first it is a minute, flattened, yellowish object, with conspicuous branching filaments, its gills, at one end and a coarse, rudderlike appendage, the tail, at the other.

The little creature at this stage can barely wriggle away from its cast-off envelope, to squirm upward to the surface of the water, where it instinctively seeks the shelter of foliage and of the shallow water, for at this age it easily becomes the prey of small fish and other ever-hungry enemies.

Its powers of locomotion are very limited, and it is unable to dart and dodge in the game of life and death, as it will have to do when it is a little older. It grows rapidly, at first living upon the nutriment from the original yolk-sac now stored in its own abdomen.

In a few days, when its mouth parts have begun to develop, it nibbles the "scum" of green algæ which forms a dense mat over every submerged stone or pebble in the stagnant pond.

The mouth of the tadpole is not at all like that of the adult frog. A sharply hooked beak, suggesting that of a parrot, but almost microscopic in size, adorns the front of the tadpole's head and is useful as a means of scraping and tearing at the minute water plants and animals which it takes for food.

At this stage tadpoles are scavengers, and fortunate are they to find the crumbs that fall from the rich man's table in the form of fragments of fish or other food left by larger and more careless banqueters in Nature's storehouse. This rich fare fattens the tadpole's body to ridiculous rotundity. His tiny, lidless eyes stare solemnly upward at the water surface, to which he must now rush every few moments for a lungful of air, as his gills are beginning to be absorbed and he has had since to depend largely on his two nostrils, equipped with valves to keep them closed and water-tight during his submarine excursioning, augmented by a spiraculum, or breathing pore, on the left side of his body.

His tail has developed to a thing of surprising strength and pliability, for on its power alone his safety depends in the increasingly bitter struggle to escape his countless enemies. Almost every carnivorous water-dweller is his enemy now. The crayfish would catch and rend him in an unwatchful moment, the water-beetle lies in wait to spring on him with tigerlike ferocity if he comes too near, the cruising turtle would find him a luscious mouthful, and the bright-eyed heron would spear him and hundreds of his brothers if they lay too long in the soft mud. Life is hard and strenuous for tadpoles, and not more than one in a hundred survives to reach maturity.

THE TADPOLE CAN GROW A NEW LEG

Before the tadpole is many weeks old a pair of budlike growths sprouts near the base of the tail, and shortly these elongate into a pair of hind legs equipped with five toes, which closely resemble those of the adult. At this stage a marvelous power of regeneration may take place, for if a toe or even a leg is nipped off, another one will grow in its place, an exact duplicate of the one lost. After metamorphosis is complete, this regenerative power ceases to function and a limb once lost is not regrown.

Some days after the legs appear, the right arm comes out. Now the little tadpole stays near the top of the water nearly all the time and seems very uncomfortable, and no wonder. His left arm is developing just where the breathing pore is located. As soon as it bursts through, his troubles are lessened, for now he can hop out on the bank in true frog fashion and breathe the air freely; for, as we have seen, his nostrils have been functioning for some time as air-breathing organs.

With the formation of his legs his head structure has likewise changed. The scraping black beak gave place to the wide mouth characteristic of the adult frog, the staring eyes acquired lids and nictitating membrane, a tympanum appeared, a definite color pattern showed on the skin, and some glandular cells arranged themselves in characteristic roughened areas all over the back.

Only the tail remains to tell of his former aquatic habits. Day by day it, too, is absorbed into the body, just as were the gills in the very early stages, until at last our little frog is completely metamorphosed and can go freely on shore with his brothers to catch flies among the plants bordering his ancestral pool.

It is now the end of July, and for the next two or three months his only occupation is eating and preventing himself from being eaten—enough to keep him busy and on the alert every instant.

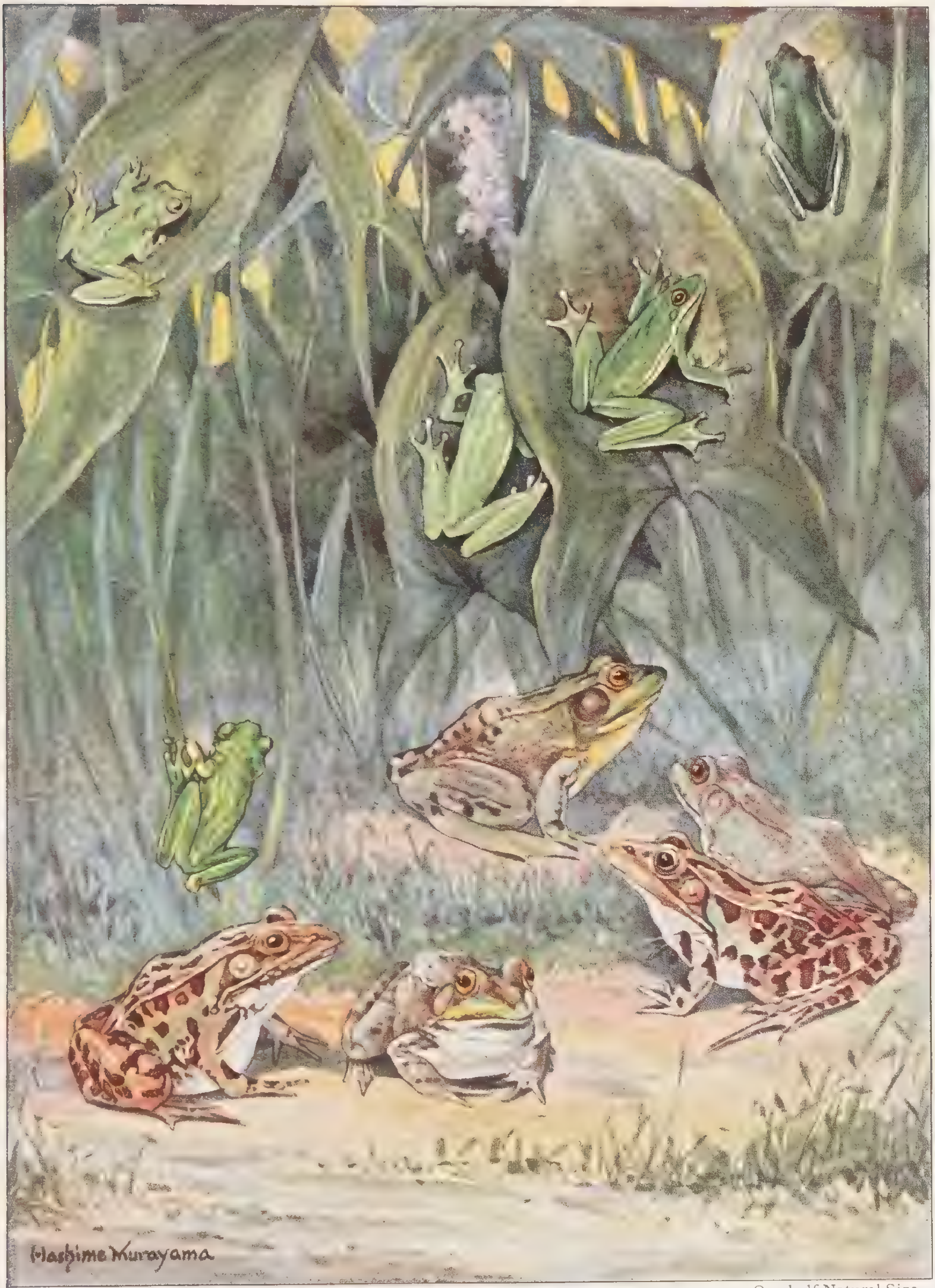
FROGS LIVE ALL WINTER UNDER MUD

At the approach of the sharp autumn weather he is about half an inch in length and half-grown. While he has no voice as yet, the mating call of his elders may occasionally be heard in the pool as late as September, for cricket-frogs are active over a long period of the year and the breeding season may be said to last from April to September, reaching a peak at several different times, as warm weather and heavy rainfall favor it.

At the onset of winter everything is silent, but with sleep, not death. Near the borders of the pond, buried under logs and stones in the mud, the little frogs have begun hibernation for the winter. A wise provision of Nature slows down their life processes to suit them to this complete inactivity and apparent inanition.

In their summer activity, more than a few moments' enforced submergence in water would have drowned them. Now, in hibernation, they can pass a whole winter beneath the mud because they are not breathing. Sometimes, indeed, a warm spell of weather in midwinter is sufficient to wake them from their lethargy, and their clicking calls may be heard in nearly every month of the year in some of our Southern States, where the winters are not severe. But the energizing warmth of the returning spring calls them to another cycle of singing and mating, and so life goes on in the little pool in the woodland.

The life history of our cricket-frog is more or less typical of that of all members of the Salientia, or tailless amphibians, which constitute one of the three existing orders of the Amphibia. The other two



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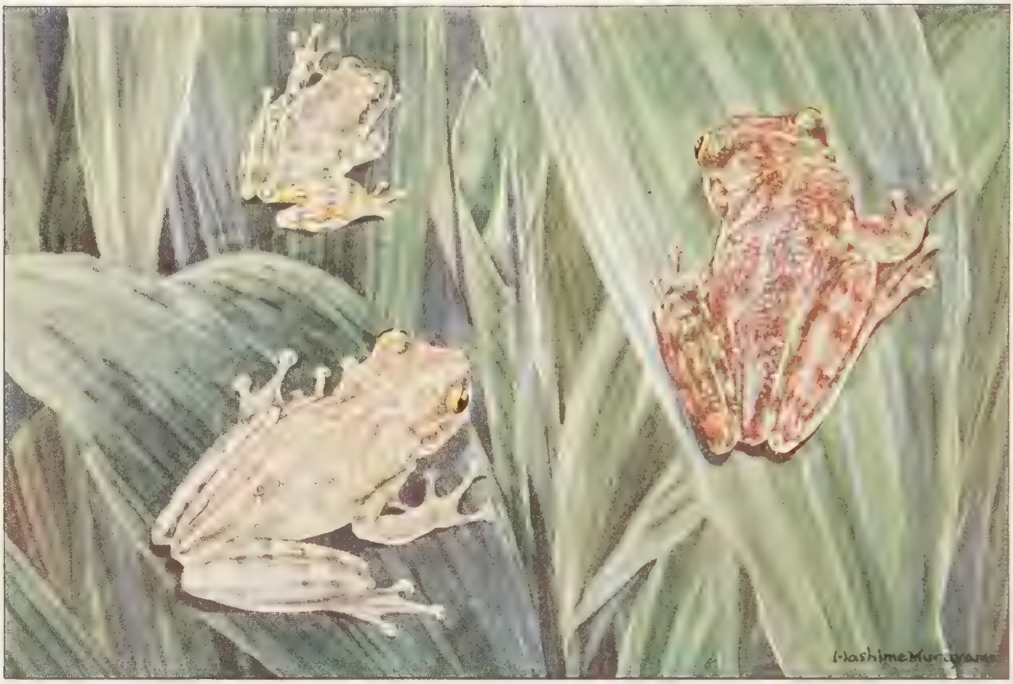
One-half Natural Size

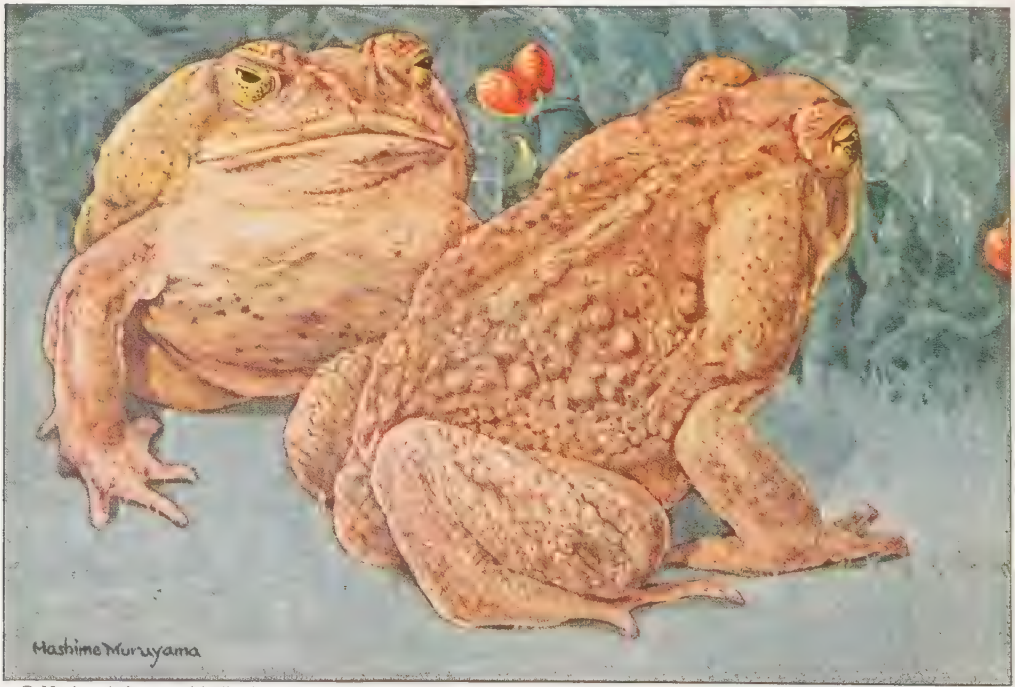
MEALTIME COMPETITION IS ASSURED IF A FLY HAPPENS ALONG

The green tree-toad, *Hyla cinerea*, [left center and four upper] is usually to be found perched upon the stalks and leaves of plants growing near the water's edge. Below, the spotted leopard-frog, *Rana pipiens*, and the green frog, *Rana clamitans*, are shown on their unceasing watch for low-flying insects which may be seized in a single well-directed leap and swallowed in one gulp.



DISKED TOES GIVE A SURE FOOTHOLD EVERYWHERE

The common tree-toad or rain-toad, *Hyla versicolor*, [upper left] is shown here away from his natural environment in order to contrast him with his large tropical cousins, *Hyla septentrionalis*, hailing from Cuba. Metachrosis, or color change, takes place in these as in most other tree-toads. A single individual will turn from dark brown to pale yellow in a few minutes, the change depending largely on atmospheric conditions, especially humidity.



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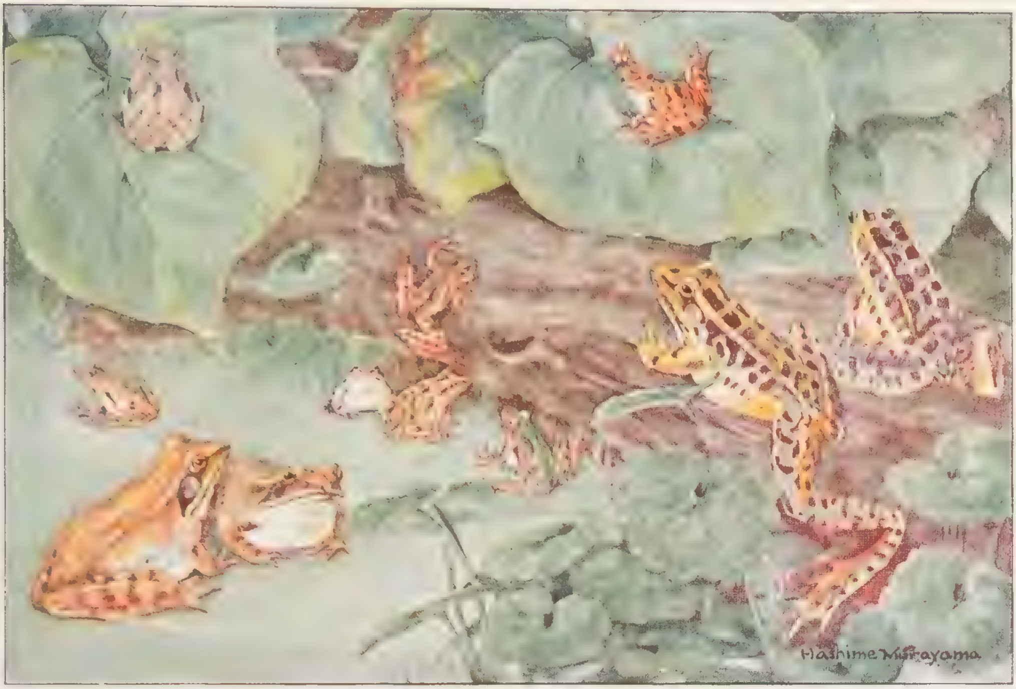
One-half Natural Size

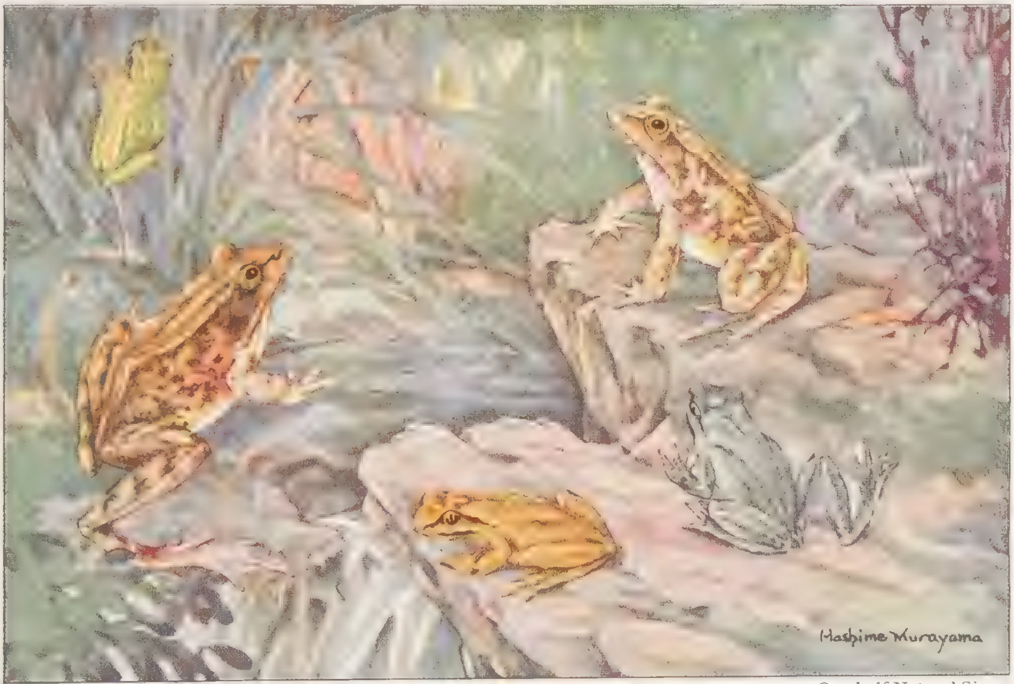
THESE ARE GIANTS IN THE TOAD FAMILY

Bufo marinus, the marine toad from tropical America, is not sea-going, as its name suggests. It is distributed over an exceedingly wide territory, however, and seems to thrive when introduced into regions where it was not previously found. In this way several of the islands of the West Indies have been populated by it, where it was brought to aid in eradicating insects harmful to agriculture.



A PONDSIDE SCENE IN NORTHERN UNITED STATES

The wood-frog, *Rana sylvatica*, [lower left] is one of our earliest harbingers of spring. The beautiful pickerel-frog, *Rana palustris*, [lower right] looks much like the leopard-frog (see Plate I) but may be distinguished by its square spots. The habits of the cricket-frog, *Acris gryllus*, [center and left] have been described in the text. The spring-peeper, *Hyla crucifer*, [upper right and left] is likewise one of the voices of early spring.



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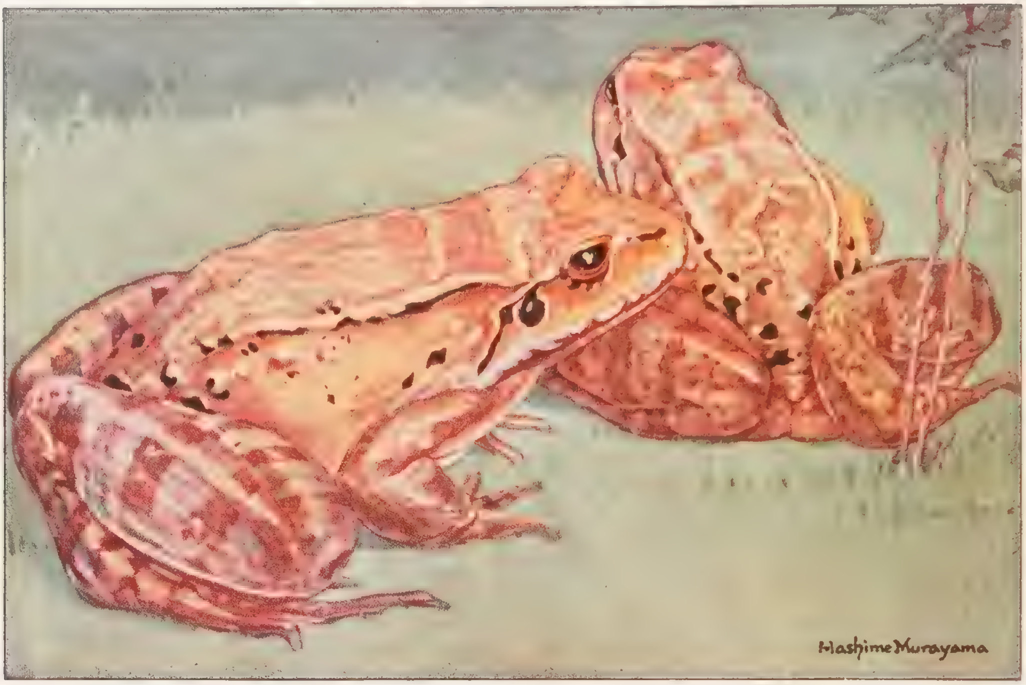
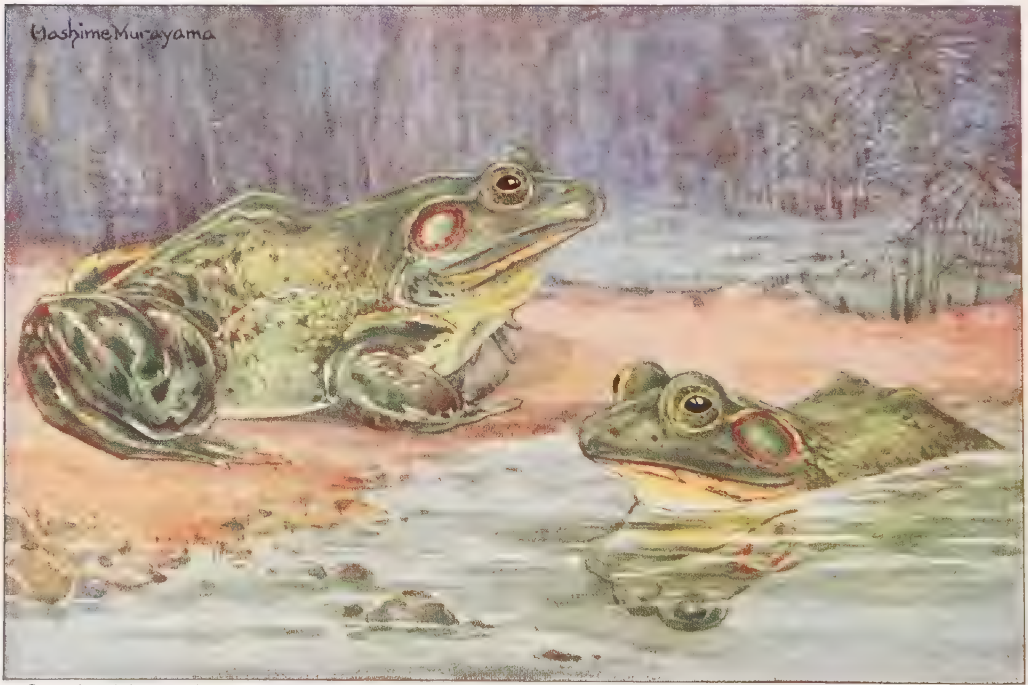
ALWAYS ON THE QUI VIVE FOR WHAT MAY COME

True's toad, *Ascaphus truei*, [lower center and right] is not a true toad in spite of its name. It belongs to a primitive and ancient family now found only in Europe, Asia and New Zealand, with this lone exile in Washington State. The cold mountain brook makes an ideal home for the shy red-legged frog, *Rana aurora*, [lower left and upper right], while the Pacific tree-toad, *Hyla regilla*, [upper left] is found in all Pacific Coast States.



AN EDIBLE SPECIES IN SOME DANGER OF EXTERMINATION

The "mountain chicken," *Leptodactylus fallax*, from the island of Dominica in the West Indies, is a large and handsome species, whose delicately toned skin suggests the texture of colored wax. The natives of the island value it as an article of food. In size it very nearly rivals our own bullfrog (see Color Plate V).



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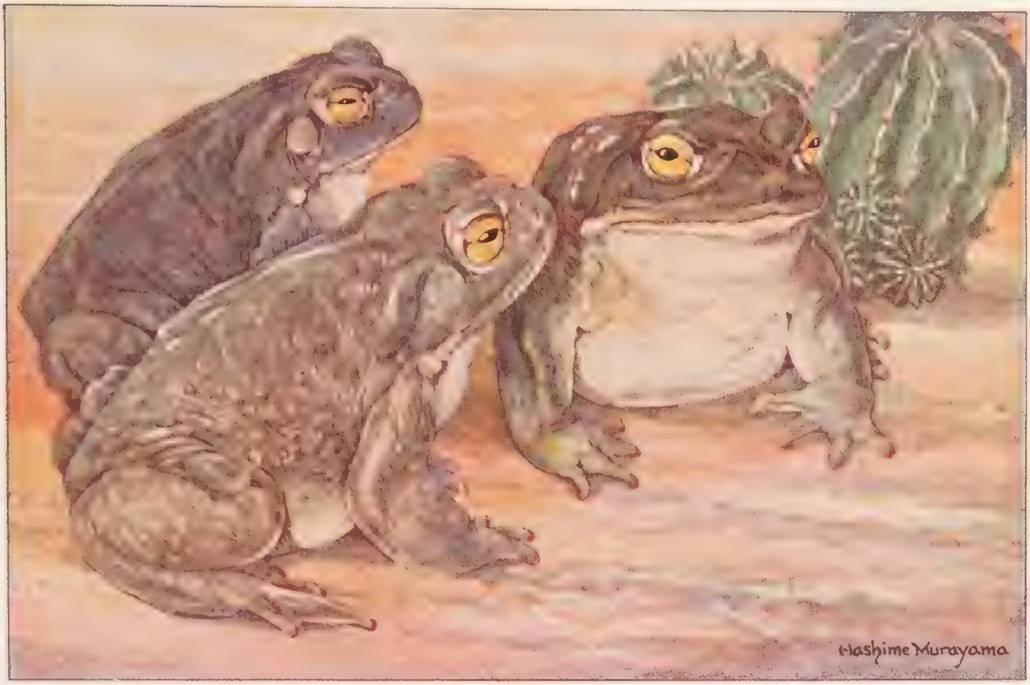
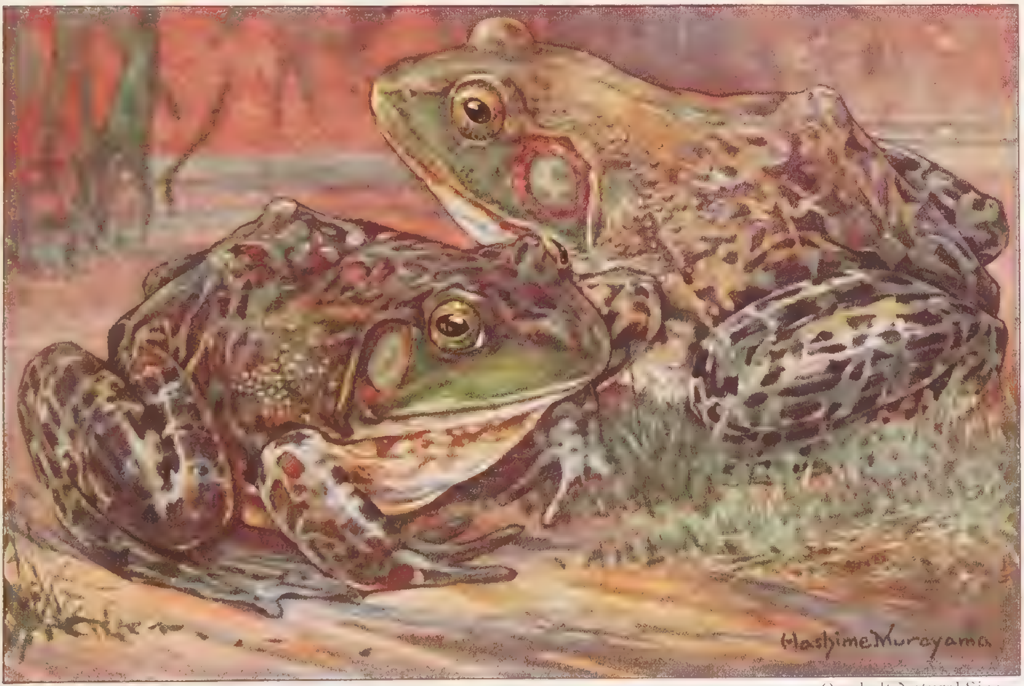
A PERPETUAL COLD BATH IS WHAT THEY ASK OF LIFE

The southern bullfrog, *Rana grylio*, is quite restricted in its range, being found from southern Mississippi to peninsular Florida. Its voice sounds like the grunting of a pig, and from this resemblance it is also known as the pig-frog.



TOADS ARE "NICE PEOPLE"

This conviction is deepened upon meeting *Bufo alvarius.* The group is as bland and philosophical as old gentlemen about to take up golf. Although they live in Arizona and in southern California, reputedly one of our most arid regions, these toads are by choice semi-aquatic. They stay near water-holes in canyons, and irrigation ditches are a boon to them.



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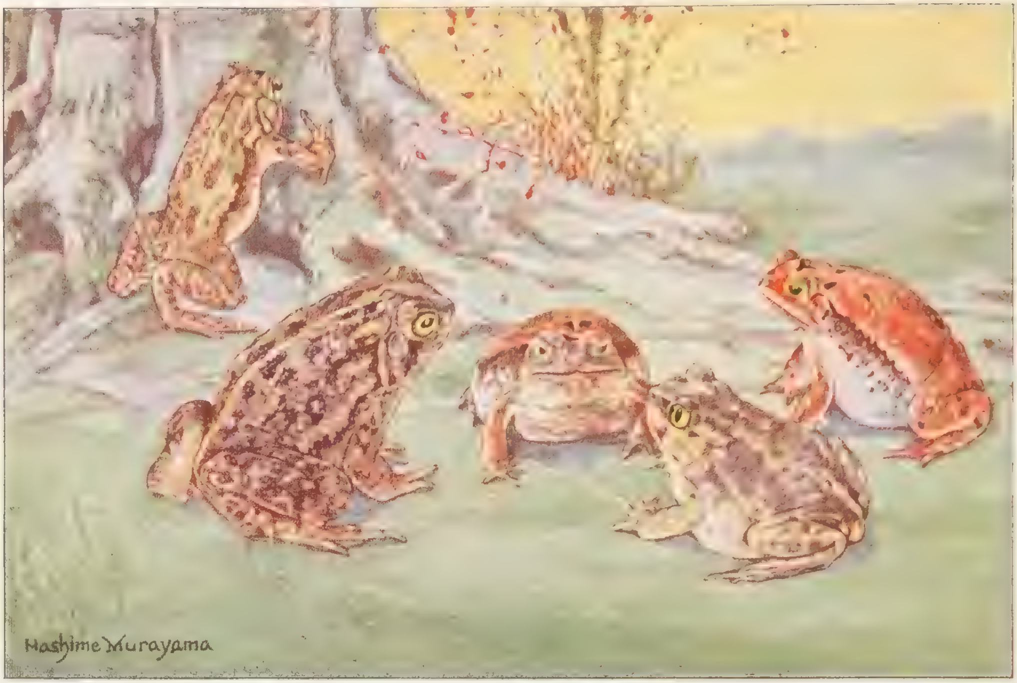
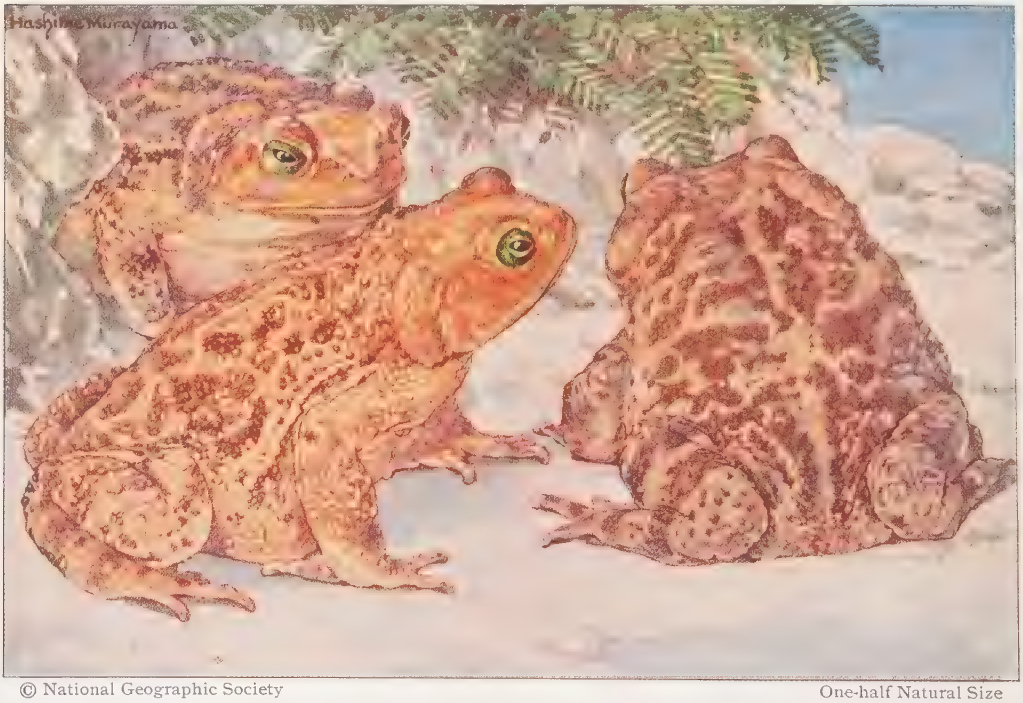
A SPECIES THAT SELDOM GOES FAR FROM WATER

The bullfrog, *Rana catesbeiana*, is the most familiar species in the United States, occurring throughout the entire country east of the Rockies. Since it is our largest frog, it is the most valuable commercially as food. It takes to deep water at the approach of a suspected danger.



ONE TOAD MAY EAT THOUSANDS OF INJURIOUS INSECTS IN A SEASON

Fowler's toad, *Bufo fowleri*, [two at left] is one of the commonest in the United States. It may be seen hopping about in the dusk, on the lookout for worms, beetles and such "fodder." *Bufo valliceps* [center and extreme right] ranges from Louisiana through Texas into Costa Rica. The spadefoot, *Scaphiopus holbrookii*, [lower right] is retiring in habits, and is almost never seen except for two or three days in the breeding season, when it resorts to ponds to lay its eggs, after which it disappears for the rest of the year.



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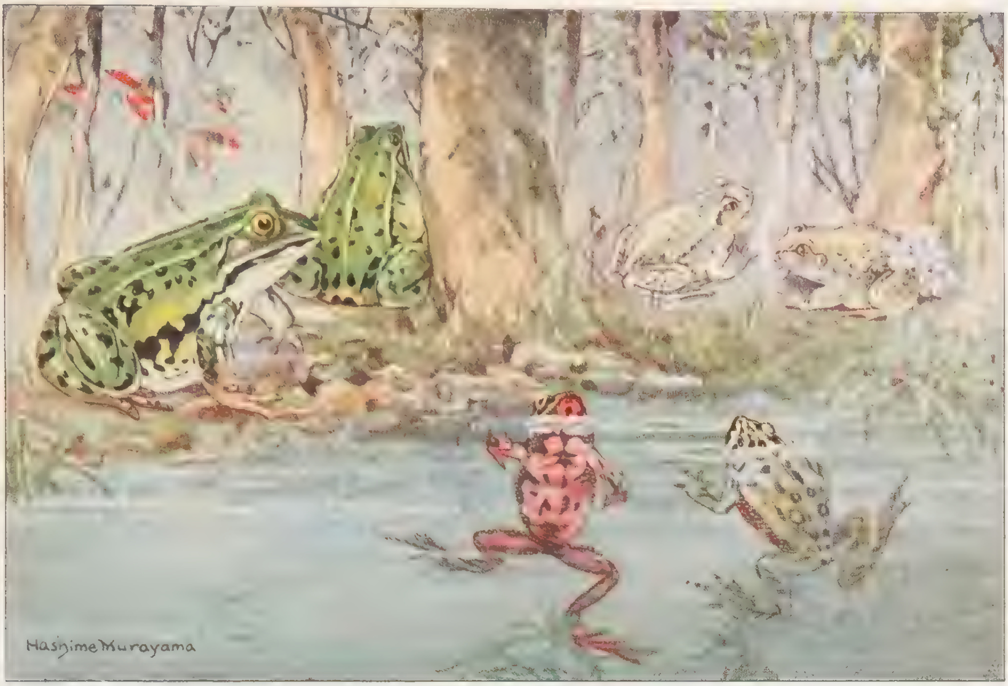
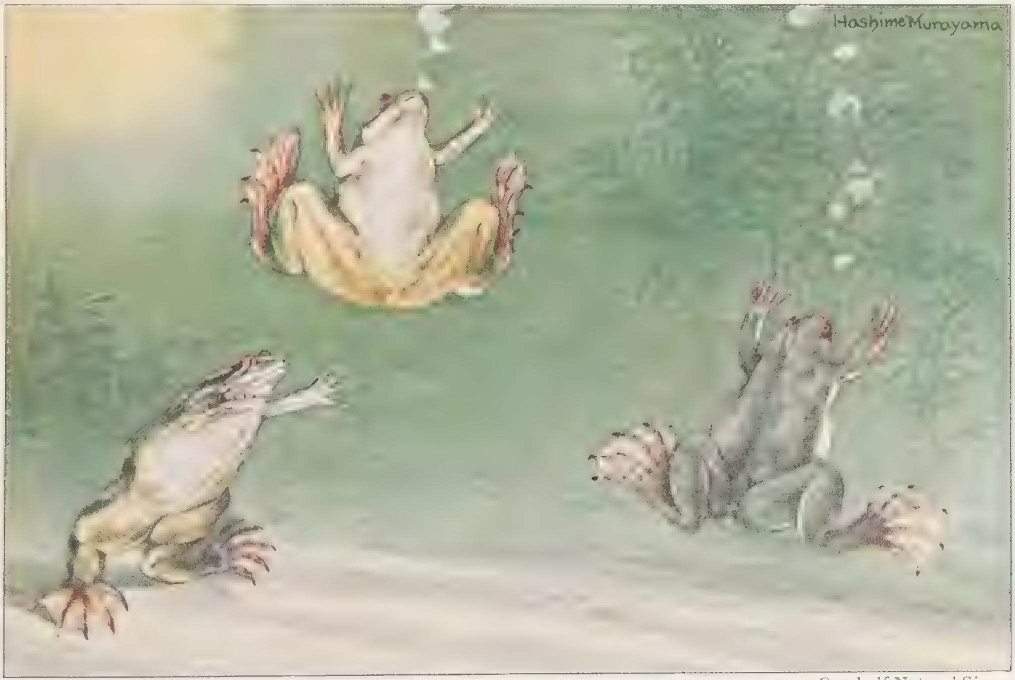
TOADS ARE FOUND ON ALL THE CONTINENTS AND ON MANY ISLANDS AS WELL

The Cuban toad, *Bufo peltocephalus*, is a beautifully marked creature, with a skin like the pattern in an old and priceless tapestry. Shakespeare himself said of a toad that he "wears yet a precious jewel in his head." Whatever a toad may lack of grace and elegance in form is atoned for in the brilliance of his eyes, which shine with glints of pure gold, amber, rose, sienna and jade.



THESE SPECIES MAKE ATTRACTIVE AND INTERESTING PETS

In Europe we find the fire-toad or bell-toad, *Bombina bombina*, [lower] an aquatic species of primitive structure related to the True's toad of Plate III. The edible frog, *Rana esculenta*, [left] is highly prized as food in Europe. A most curious example of paternal solicitude occurs in the midwife toad, *Alytes obstetricans*, [right] in which the male takes the long strings of eggs as soon as the female lays them and wraps them around his body, hopping to the water's edge to moisten the eggs daily as they require it.



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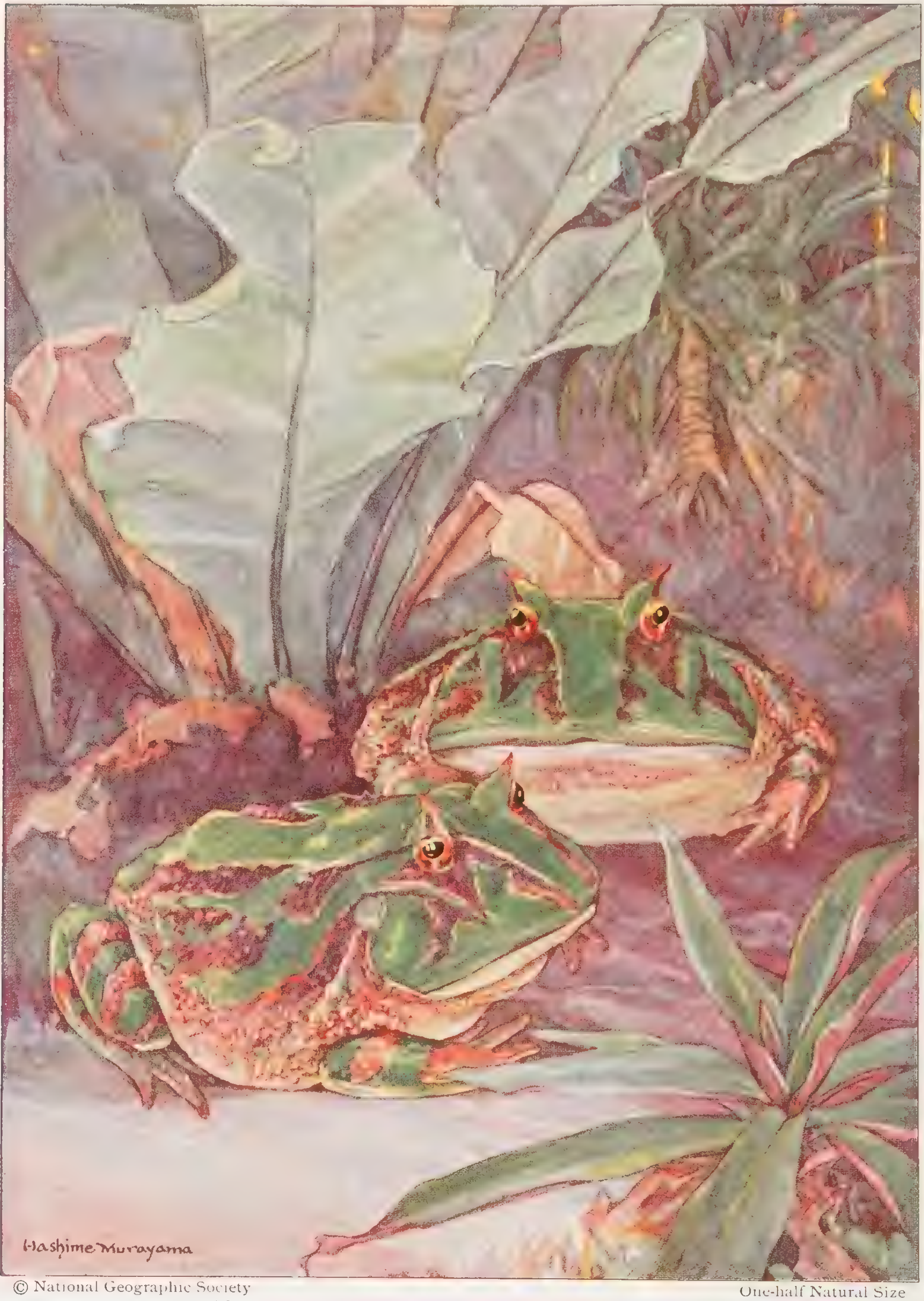
SUCH CLAWS OCCUR RARELY AMONG AMPHIBIANS

The Aglossa; or tongueless frogs, are here represented by the clawed *Xenopus mülleri* from East Africa. They are entirely aquatic, and hunt for their food in the mud, stirring it up with their long fingers and seeming to find it rather by touch than by sight. They must go occasionally to the surface of the water for a lungful of air, which lasts them for several minutes.



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AGGRESSIVE AND CANNIBALISTIC HORNED TOADS

The true horned toads belong to the genus *Ceratophrys* from South America. This species, *Ceratophrys dorsata*, is a native of Brazil. It lives in dense forests, where its coarse pattern of brown and green makes it nearly invisible on the carpet of green leaves and brown roots. The horned lizard, *Phrynosoma*, from the western United States is often erroneously referred to as the horned "toad."

orders are the Caudata, or salamanders, and the Apoda, or cæcilians.

TWO THOUSAND SPECIES OF "FROGS" AND "TOADS"

While there are about two thousand species of tailless amphibians, we lack a corresponding number of common names for them. We must perforce call everything by the name of "frog" or "toad," although the several families grouped together as "toads," for instance, may be as different structurally and in habits from the true toad, genus *Bufo*, as the lion is different from the camel, although both are mammals.

While most tailless amphibians deposit their eggs in water, with the tailed aquatic tadpole stage intervening between egg and adult, there is one tropical American genus, *Eleutherodactylus*, in which the young frog completes his metamorphosis entirely inside the egg-capsule, and when it is finally time for him to sally forth he comes out and hops away among the tree tops with no tail to impede him.

Other tropical frogs lay their eggs in the rain-filled axils of giant palm leaves perhaps a hundred feet high in the air. Here it is truly a case of rock-a-bye, baby, on the tree top to the little frog baby.

In his wind-rocked cradle of rainwater he may have strange bedfellows. Such a bromeliad reservoir from Jamaica yielded a young *Eleutherodactylus* and tadpoles belonging to two species of frogs, some small crabs, grasshoppers, arboreal cockroaches, a tarantula, and some earthworms, which live high in the air in the quart or two of soil and water which collects in the junctions of leaves with stem.

SHOWERS OF FROGS

"Showers" of frogs and toads have been mentioned in the literature of very early times, and, while some of the tales are exaggerated, we know that showers of organic matter actually do occur when the entire contents of a pond are sucked up by a whirlwind and dropped perhaps miles away from their point of origin. One of the early accounts is by Athenæus and dates from about A. D. 200. In a chapter entitled "De pluvius piscium," he says:

"I know also that it has very often rained fishes. At all events Phænias, in the second book of his Eresian Magistrates, says that in the Chersonesus it once rained fish uninterruptedly for three days; and Phylarchus, in his fourth book, says that people had often seen it raining fish, and often also raining wheat, and that the same thing had happened with respect to frogs.

"At all events, Heraclides Lembus, in the 21st book of his history, says: 'In Pæonia and Dardania, it has, they say, before now rained frogs; and so great has been the number of these frogs that the houses and the roads have been full with them; and at first for some days the inhabitants, endeavoring to kill them and shutting up their houses, endured the pest; but when they did no good, but found that all their vessels were filled with them, and the frogs were found to be boiled up and roasted with everything they ate, and when besides all this they could not make use of any water, nor put their feet on the ground for the heaps of frogs that were everywhere, and were annoyed also by the smell of those that died, they fled the country.'"

Several authentic accounts of more recent rains of frogs have been published in scientific journals, mostly in Europe. One account states that during the storm that raged with considerable fury in Birmingham, England, on Wednesday morning, June 30, 1892, a shower of frogs fell in the suburb of Moseley. They were found scattered about several gardens. Almost white in color, they had evidently been absorbed in a small waterspout that was driven over Birmingham by a tempest.

Peculiar superstitions exist about toads and frogs in many countries. Since most races of men observe closely only those creatures which are either directly useful to them or potentially injurious, the majority of the amphibians escaped anything resembling close and protracted study until relatively recent years. It was not until about two centuries ago that the facts of hibernation were definitely made known to science. Before that time it was believed that frogs were procreated from the mud—an idea proposed by no less an observer than the illustrious Aristotle himself.

In Europe, in the Middle Ages, the toad was supposed to be an intimate of the alchemist and the sorcerer, itself endowed with supernatural powers. Credulous sick people were dosed with ghastly concoctions and strange brews of various inedible substances often including a toad or frog, and

Photograph by Lynwood M. Chace

A LEOPARD-FROG WITH EGGS

A single egg mass may contain between five and six thousand eggs. So many dangers beset them and the subsequent tadpoles that perhaps only one out of this mass may live to metamorphose.

over which the wizard healer had said weird incantations supposed to make the evil spirit depart from the body of the sick.

The toadstone was long sought by even those best informed and least credulous. The beautiful, gleaming eye of the toad was supposed to be an outward sign of the inward luster of the jewel concealed in his head. The toadstone was considered to be endowed with therapeutic qualities and to be an effective antidote for poisons. It was carried as a charm, set in a ring or worn as an amulet, or deposited on the shrine of a saint as an offering of great piety.

THE TOAD IS UNJUSTLY CHARGED WITH CAUSING WARTS

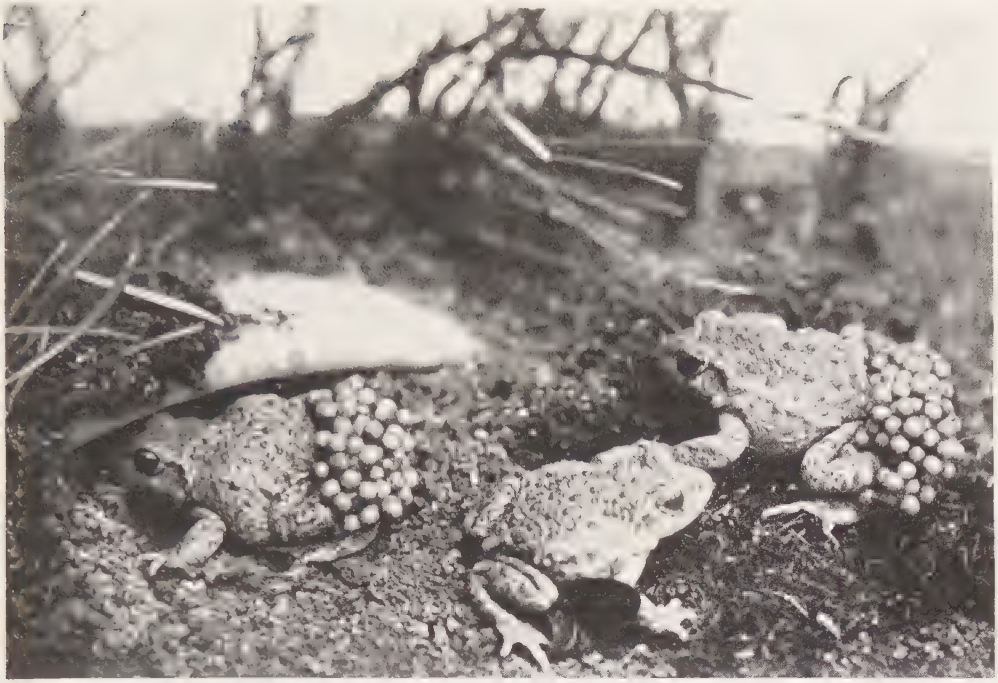
Almost as naïve is the belief, common in most parts of the United States, that the handling of toads will cause warts. While toads appear to have warts themselves, due to the swollen glands in the skin, they cannot cause warts, nor can they harm the skin in any way. I myself present proof of this statement. I have kept pet toads for several years and have handled them almost daily, and my hands are absolutely without warts. The only wart I ever had on my hands was during the comparatively toadless period of my high-school days, and even that one went away soon after I began playing with toads.

After handling toads, however, care should be taken not to get any of the mucous secretion from the skin glands into one's eyes or mouth, as serious trouble might ensue.

The use of toadskins as medicine in China may be more reasonable than it appears. Recent studies of the secretion of the parotoid glands of the toad reveal chemical changes taking place within the matured secretion producing adrenalin.

Primitive tribes have long been familiar with the uses of poisons obtained from various kinds of tailless amphibians. In Colombia the Indians poison their arrows with a secretion from the small, brilliantly colored *Dendrobates tinctorius*, which is less than two inches in length when fully grown. By exposing it to heat near a fire, sufficient poison may be scraped from the back of one individual to poison fifty arrows.

The principal use of this same toad, however, is in "dyeing" parrots. The green and



Photograph by Paul Henri Fabre

THE FEMALE OF THIS SPECIES IS FULLY EMANCIPATED

In the case of the midwife toad, *Alytes obstetricans* (see Plate VII), the female (center) has no further responsibilities after she has laid her eggs. The male toad (right and left) takes the greatest care of the eggs until hatching time, and appears to like his parental duties, as several batches of eggs may be thus "incubated" by him in one summer (see, also, text, page 650).

blue feathers on the head and neck of the Amazon parrot are plucked out in some fanciful pattern, and the bare skin in these areas is touched with the skin of a living *Dendrobates,* and again after the young feathers have begun to appear. When the feathers finally grow in, they are yellow instead of green. There is considerable demand for these artificially colored birds in the South American countries.

Another quite dissimilar utilization of toadskins by the orientals is in the fabrication of small articles such as purses. For this purpose the leather is admirable, being soft and thin, yet very strong, with a pleasing texture when prepared by experts.

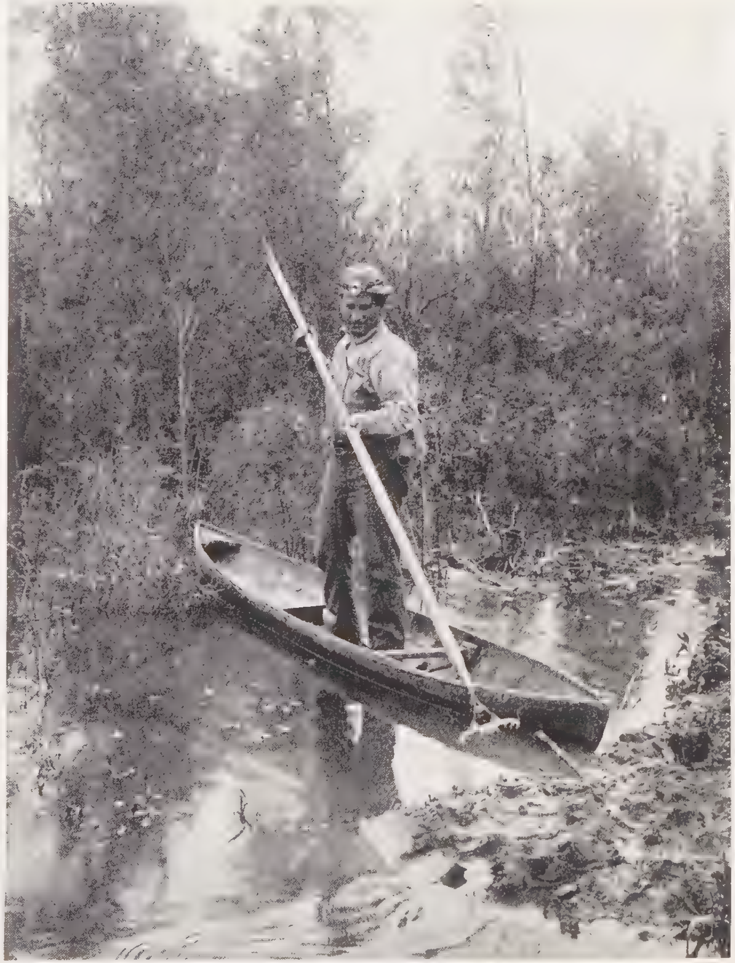
THE MUSCULAR POWER OF FROGS

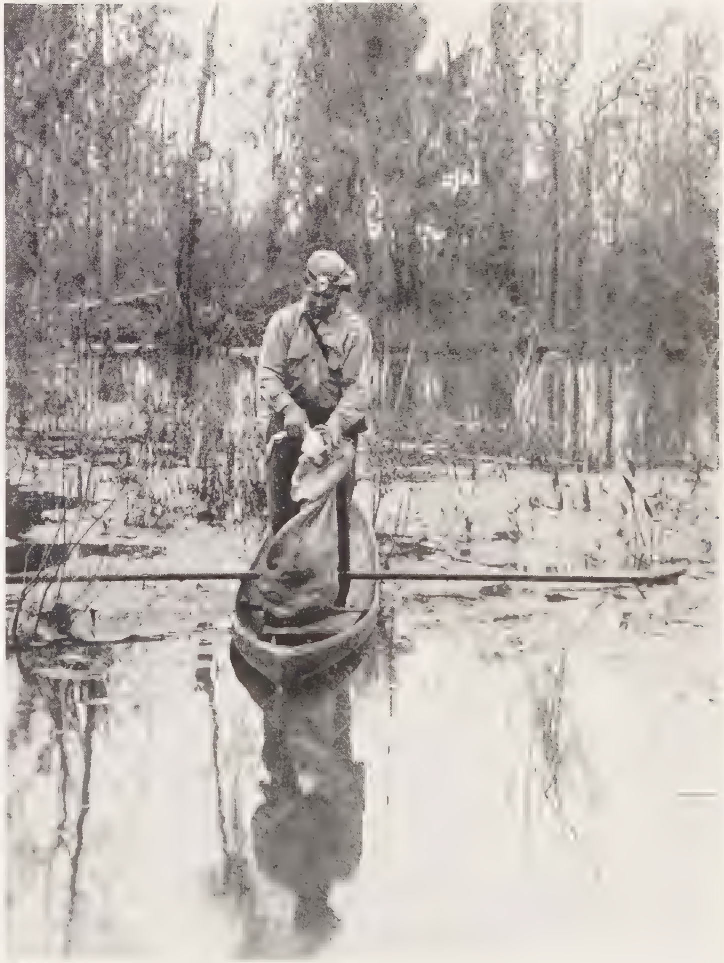
The leaping powers of the average frog are such that the best records of our Olympic athletes are distinctly put in the shade by them. A man can make a running jump of not much more than four times his length, while any two-inch frog worth his salt thinks nothing of a jump of twenty times his length.

The gliding habit is much more unusual among frogs. In Brazil some experiments were conducted with one of the tree-toads, *Hyla venulosa,* which proved that it would leap voluntarily into the air from a height of 40 feet, spreading its legs to break its fall and landing unhurt after its gliding descent. One specimen was released from the top of a water-tower 140 feet in height when a slight breeze was blowing; it landed uninjured on the ground 90 feet from the base of the tower. If thrown high up into the air, it managed to right itself every time, so that it came down on its feet. The frog is no more able to fly in the true sense of the word, however, than is a falling leaf.

The insect-eating habits of the tailless amphibians are of great economic value to man. Toads especially take enough food to fill the stomach completely four times in 24 hours, and they have been truly valuable in fighting an outbreak of sugar-beet webworms.

Man utilizes frogs' legs as food in many parts of the world. They are collected for market on a commercial scale in some





Photographs courtesy Ozio Fisheries

CAPTURING A FOUR-POUND BULLFROG IN LOUISIANA

The specially designed frog gig which is operated with a trigger on the handle catches the frog but does not kill it.

HE PLACES HIS LIVE CATCH IN A SACK

Note the flashlight on the cap, like a miner's lamp, which the trapper uses in stalking his prey at night.

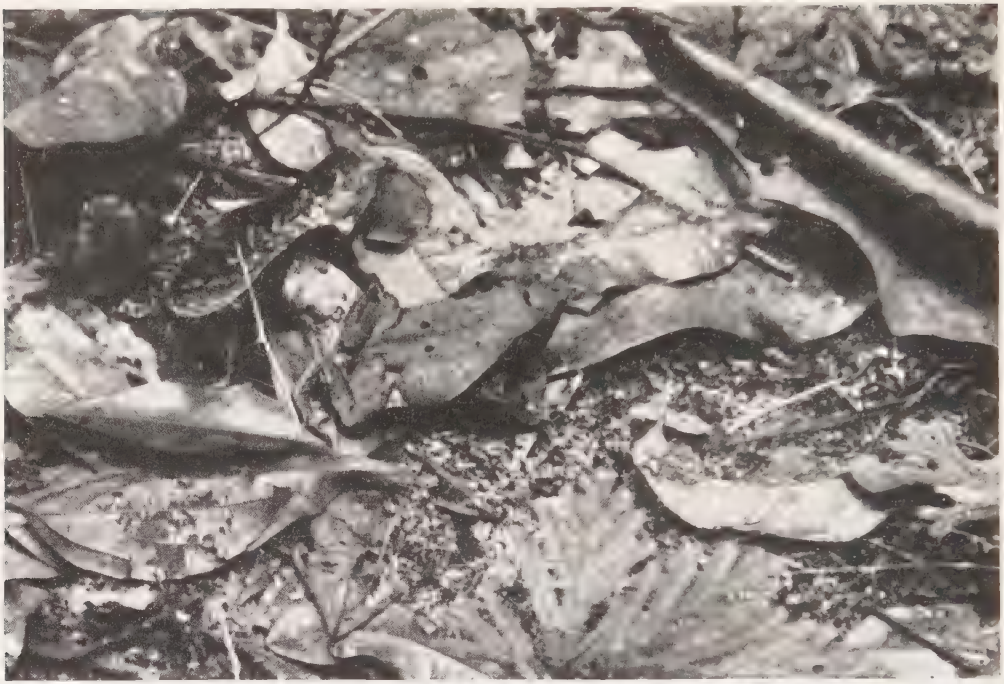
Photographs by Clifton Adams

PURCHASING FROG LEGS IN A WASHINGTON, D. C., MARKET

While practically all frogs are edible when skinned and cooked, only the largest species are of any practical importance in commerce. In the United States the bullfrog supplies the market (see text, page 654).

TO BE SERVED TO EPICURES

The chef of one of the most famous restaurants of the Nation's Capital skinning a shipment of six dozen "medium" frogs just received from a "Cajun" dealer west of New Orleans, Louisiana.



Photograph by Hugh B. Cott

A PAST MASTER IN THE ART OF CAMOUFLAGE

The toad in the center of the photograph (*Bufo typhonius*) so closely resembles a leaf that it escapes the notice of its enemies on Marajó Island, Brazil.

fifteen States of the Union, but "frog farms" have not proved successful because of the difficulty in providing the adults with live food. After he has emerged from the larval or tadpole state Sir Frog becomes fastidious about his fare, refusing all nourishment except that which is living or moving (see text, page 630).

While the nutritive value of frogs' legs compares favorably with that of chicken and fish, it is the delicacy and palatability of the flesh which place them in the front rank of epicurean luxuries (see, also, sketch of the Edible Frog, page 654).

MAKING A HOME FOR FROGS

While amphibians are not yet quite as popular for pets as tropical fish,* they are no less interesting. Once their special requirements are understood, they become charming inmates of one's vivarium case. A word as to the installation of such a "live box" may not be amiss.

Any wooden packing box a yard long, a foot wide, and two feet high will make a satisfactory case if one side is either glassed or screened for observational purposes and a screen or cover of some sort is made to fit very tightly over the top of the receptacle. Now add a six-inch layer of moist earth and in one corner sink an earthenware saucer to hold water.

The moist soil may be covered with moss from the woods, planted with ferns, and decorated with flat stones and pieces of bark, under which the small inmates will be glad to retreat at times.

Now to stock our vivarium! If we go forth with a flashlight on a warm spring night to almost any small body of fresh water, the light will attract some kind of amphibian which may be in the vicinity. He may be picked up and put in a container half-filled with moist leaves to supply the proper humidity, for all amphibians require considerable moisture and will very soon die if deprived of it.

Tree-toads, cricket-frogs, the common or garden toad—all these will soon become tame in captivity and will eat readily the flies, angleworms, and other living food that may be supplied to them. While a

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* See "Tropical Toy Fishes," by Ida Mellen, in the NATIONAL GEOGRAPHIC MAGAZINE for March, 1931.

Photograph by Dr. A. H. Wright

THE OAK TOAD'S LITTLE THROAT, LIKE THAT OF THE CRICKET-FROG, BUBBLES MADLY UP AND DOWN IN HIS MUSICAL ENTHUSIASM TO ATTRACT HIS MATE

The inflated vocal pouch of the calling male extends in front of the head. The smallest of his kind, *Bufo quercicus*. He is to be found in oak and pine woods from North Carolina south to Georgia and Florida.

number of different species may be kept in the same vivarium, the inmates should be approximately equal in size, as big frogs become cannibalistic toward their small brothers whom they see hopping about and whom they fail to distinguish from a moving beetle or other legitimate food.

The necessity of a tightly fitting cover arises from the fact that the tree-toads especially are adept at squeezing themselves through unbelievably small crevices and thus taking French leave.

After such an escape in one's home, they seem invariably to hop under the most awkward pieces of furniture, from which their owners can extricate them only with considerable effort. Any lady who keeps a pet frog seldom needs to go on a reducing diet, as she will get exercise enough in recapturing her pet when he escapes back of a piano or under a sofa.

Frogs in captivity frequently delight and surprise their owners by their vocalistic prowess. They appreciate the radio program, and there is something in the sound of the xylophone which invariably sets the little cricket-frogs to piping. A political speech likewise elicits considerable comment, no matter what the platform may be! One's pet bullfrog may decide to sing at 3 o'clock in the morning, however, and then the humor of the situation is not so apparent to some people.

I have not spoken of the real beauty of some species of frogs. Their slender, graceful proportions; their waxlike, nearly translucent skin, glowing with the soft, rich tones of old pottery; their brilliant, expectant eyes, with irises of gold and iridescent colors—these are sufficient to make an esthetic appeal to anyone who is sensitive to beauty in all of its forms.

MÜLLER'S CLAWED FROG: Xenopus mülleri

(*See Color Plate VII*)

Complete adaptation to an aquatic existence is shown by these tongueless frogs. Their fingers are elongate and highly tactile to help them to locate insects burrowing in the mud, while their powerful webbed hind feet carry them easily through the water to seize fish, swimming insects, and even their own tadpoles. Their nostrils close with valves, and they need go up for air only two or three times in an hour.

In captivity they often stay at the surface with only their nostrils and their lidless eyes projecting above the water, and if a piece of raw beef or an insect is held an inch or two above the water, they will leap up and take their food from one's fingers. They are extremely hardy in an aquarium if given the simple care that they require.

AMERICAN BELL-TOAD OR TRUE'S TOAD: Ascaphus truei

(*See Color Plate III*)

These remarkable amphibians live in mountain brooks in which the water is less than 40° Fahrenheit, where they conceal themselves by hiding under stones at the bottom of the stream. In captivity they must be kept in water with melting ice or in the refrigerator; otherwise they will die from too much warmth.

This species is the only one which possesses an extension of the cloaca in the male. Fertilization is internal. The tadpole clings with the mouth to a stone in swift or still water to keep itself from being swept downstream, and occasionally even fastens itself to a rock in the falls.

EUROPEAN BELL-TOAD OR FIRE-TOAD: Bombina bombina

(*See Color Plate VII*)

This toad, like many other species, produces a slimy, poisonous secretion from the glands on its back when it is annoyed. If it cannot escape, it bends itself backward, showing the brilliant flaming color of its underparts, and likewise displays the bright undersurfaces of its hands and feet as a warning to its pursuers that it is not edible.

In captivity the bell-toad makes a charming pet, living among the water plants in a screened aquarium and soon learning to take food from the hands of its owner. Its voice is very faint, but musical and bell-like. It rests near the surface of the water, with its limbs spread, showing nothing above the surface except its nostrils and its round, projecting eyes. It is found in the lowland ponds from Russia to Germany.

THE MIDWIFE TOAD: Alytes obstetricans

(*See Color Plate VII*)

A lengthy literature exists on the unusual breeding habits of this European species, in which the male frog assumes the care of the eggs for the three weeks during the entire period of their development, going about at night to obtain his food and to immerse the eggs in the water for a short time during very dry nights, and retiring by day to a shallow burrow or to a crevice between stones (see page 645).

When the male finally enters the water to release his burden, some glands on the nose of the tadpoles digest the egg envelope, freeing the embryos, which swim away.

The female is able to spawn three or four times a year, so that the male is kept busy with family cares during the whole summer. Larvæ hatched in the spring may complete their metamorphosis before hibernation, but the latest brood retains the tadpole form, living in the deepest water, under the ice, until the following spring, when the transformation can be continued.

THE HERMIT SPADEFOOT: Scaphiopus holbrookii

(*See Color Plate VI*)

Except for a few days at the breeding season, when it resorts to ponds to lay eggs, this species is virtually never seen in the open. It is the most secretive of any of our native frogs, and burrows deeply into the ground with the sharp horny ridges on the soles of its hind feet. Here it stays for weeks and months at a time in a hibernating position, its head lowered over its front feet, its eyes shut, and its sides puffed out, so that it looks like a round ball. It emerges to look for food only after heavy rainfall and at night. Its breeding period lasts only a night or two, at which time its discordant croaking can be heard for a long distance. It ranges over the eastern and southern United States.

THE COLORADO RIVER TOAD: Bufo alvarius

(*See Color Plate V*)

While not the largest known species, *Bufo alvarius* nevertheless attains the distinction of being the largest toad found within the borders of the United States, its head-and-body length being more than five inches. Its smooth greenish skin causes it to resemble a frog more than a toad, while its semiaquatic habits heighten the similarity.

The heavy glands, appearing not only on the parotoid region, but likewise on the upper surfaces of the arms and legs, afford it an unusual degree of protection, for their secretion is highly poisonous, and has been known to cause immediate death to a dog which rashly molested one. Only great stress of fear or pain causes the poison to be sweated from these glands, however, for captive specimens gently handled never display the slightest trace of it, even when they are forcibly fed.

FOWLER'S TOAD: Bufo fowleri

(*See Color Plate VI*)

Hopping about in the pine woods at dusk, picking up slugs and beetles, this toad may be found from New England to Georgia and central Texas and north to Michigan. Its eggs are laid in long strings in the water, as many as 5,000 eggs being deposited by a single female at one time. Infant mortality is tremendous among the small black tadpoles which later swarm in the pool, as well as among the countless minute toadlets which have completely metamorphosed.

THE MARINE TOAD: Bufo marinus

(*See Color Plate II*)

Hailing from tropical America, this creature has the distinction of being the giant of all toads. A well-grown individual will measure eight inches in length as he sits, and his waist-

Photograph by Lynwood M. Chace

WITH BRUTAL COMPLACENCE THE AMERICAN TOAD FEASTS UPON A SPICE-BUSH SWALLOW-TAIL BUTTERFLY

After he swallows the body of his prey, *Bufo americanus* may use his short, chubby hands to cram the stiffly spreading wings into his mouth.

line achieves the magnificent figure of thirteen inches.

The true toads, those belonging to the genus *Bufo*, may be recognized by the presence of an enlarged parotoid gland, which secretes an acrid slime, the toad's only means of defense against his enemies. This is highly irritating and sometimes fatally poisonous when applied to the mucous membrane of the mouth of dogs, wolves, and other enemies of the toad, so that a wary dog cannot be persuaded to bite a toad after he has had one experience with this glandular secretion.

While the other tailless amphibians have glands in the skin which are more or less active, only the toads have the enlargement at the parotoid region (above the ear), and in this species the parotoid gland reaches a maximum development.

SAPO OR CUBAN TOAD: Bufo peltocephalus

(*See Color Plate VI*)

This species was thought to be rare in Cuba until its habit of congregating beneath stones on hillsides and under the roots of trees was thoroughly understood, when it was found to be very widely distributed on the island.

Like most tropical amphibians, this toad is nocturnal. There is no necessity for hibernation; hence it is able to feed during the entire year. The thick and warty skin is much better adapted to stand dryness than is the frog's skin, so that the toad is able to travel overland away from wet areas, although it has to retreat into a damp spot frequently to avoid too much desiccation.

THE NEBULOUS TOAD: Bufo valliceps

(*See Color Plate VI*)

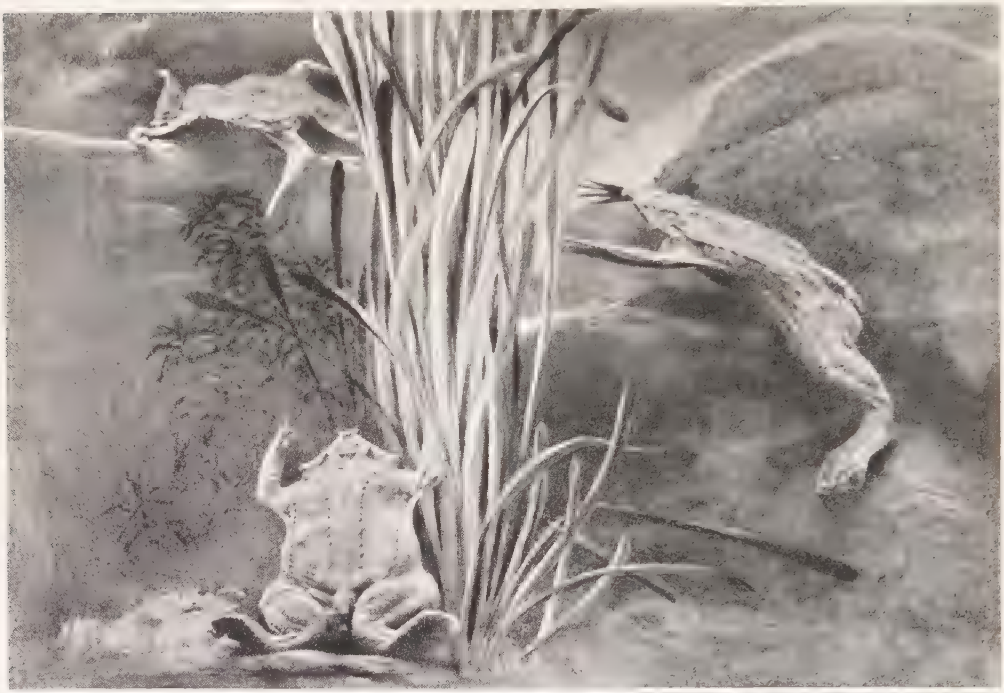
The sharp, high cranial crests, emphasizing the abrupt contours of the head, distinguish this toad readily from all others found in the United States. Its coloring is variable, but often ruddy or brown, this characteristic extending even to the eye, which is a combination of copper and sienna outlined with gold.

In captivity the nebulous toad makes a contented and amusing pet, readily accepting insects shaken in front of its face on the end of a straw, or doing battle valorously with a huge angleworm and finally using both hands to cram it willy-nilly into its mouth. It is fond of snails also.

THE COMMON TREE-TOAD OR RAIN-TOAD: Hyla versicolor

(*See Color Plate II*)

Widely distributed through the United States from the Atlantic coast to the Mississippi and from the Gulf of Mexico into southern Canada, the rain-toad is known to most of us fortunate enough to dwell in the country. His musical, bell-like voice haunts the orchard, and the fact



THE SURINAM TOAD HAS NO FREE-SWIMMING TADPOLE STAGE

Although limited to the northeastern part of South America, where it leads an entirely aquatic existence in the pools and inundated areas, this tongueless (Aglossid) amphibian (*Pipa pipa*) has long been kept in aquaria in zoölogical gardens because of its remarkable breeding habits. At the time the eggs are laid the male distributes them evenly over the back of the female, and each egg comes to lie in a deep pouch in the skin, closed by a peculiar lid, which is probably the remnant of a membrane originally surrounding the egg. Within this cavity the egg develops through the tadpole stage, and the young one, fully metamorphosed, leaves his prison and swims away from his mother to live his own independent life.

that he prefers to sing in the rain has earned him one of his names. On the lichen-covered bark of trees, it is next to impossible to see him, for his gray-and-olive spotted coloring makes him a perfect match to the branch to which he clings. He is most active in the evening and at night, sleeping by day on a tree trunk or some other vertical surface to which his sticky toes adhere without any effort on his part.

THE GREEN TREE-TOAD: Hyla cinerea

(*See Color Plate I*)

Perhaps the most beautiful of our native tree-toads, this species is likewise one of the most satisfactory in the vivarium. A never-failing appetite for flies is one of this frog's very desirable qualities. It becomes exceedingly tame in a short time and soon learns to appear in readiness at the regular hour for feeding. Its long limbs give it a graceful slenderness which some other species lack. Its color is always some tone of green, to which the lustrous white or yellow lateral stripe adds a pleasing contrast. It occurs in the southern United States and as far north as Virginia.

THE SPRING-PEEPER: Hyla crucifer

(*See Color Plate III*)

The birdlike piping melody of the spring-peeper may be heard as early as February or March, for it is one of the earliest of the amphibians to appear in the spring. In chorus close by, the sound effect is too ear-splitting to be listened to for very long; but as these frogs are extremely shy, the song ceases at the approach of a human being. The loudness of the song seems all out of proportion to the size of the singers. The species is found in southern Canada, south to the Carolinas and Louisiana.

THE PACIFIC TREE-TOAD: Hyla regilla

(*See Color Plate III*)

While this species has well-developed disks for climbing on its toes and fingers, it seems to prefer to remain on the ground, among the undergrowth, near shallow ponds. From these concealed spots its call may be heard sometimes in winter. Dark, rainy days and early evenings bring a full chorus, especially in February, at which time the egg-laying begins. Metamorphosis may be completed in April. The young frogs are then only half an inch in length, but attain their full size, an inch and three-quarters, by the next breeding season.

THE CUBAN TREE-TOAD: Hyla septentrionalis

(*See Color Plate II*)

This species is larger than any of the tree-toads found in the United States, attaining a head-and-body length of at least four inches. It does not have to hibernate, since there is no freezing weather in its tropical home. It takes prodigious leaps through the tree tops at night in its search for moths and other night-flying insects, as well as for small frogs and anything else of suitable size. Its head is peculiar because the skin is involved in the cranial ossification. It is said that when these "bone-headed" species, of which there are several, retire into a hole in a tree to sleep, the top of the head is used as an effective plug to the hole, so that enemies are kept out.

THE CRICKET-FROG: Acris gryllus

(*See Color Plate III*)

The salient points regarding this frog have been outlined in the text (see pages 629 to 634). The cricket-frog might be confused with the swamp tree-frog *Pseudacris*, which has no pronounced webs between the toes and which has a much smoother skin. It might also be confused with the newly metamorphosed frogs of the genus *Rana*, but a glance at the profiles of the heads should settle their identity, for in *Acris* the part of the head anterior to the eyes is unusually prolonged, while in *Rana* it is shorter, as a rule.

In spite of its diminished toe-disks and consequent inability to do much climbing, it is properly grouped with the tree-toads in the large family Hylidæ.

THE MOUNTAIN CHICKEN: Leptodactylus fallax

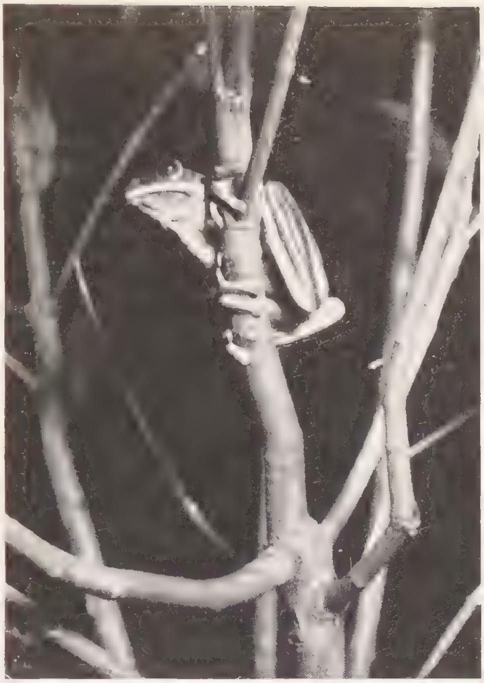
(*See Color Plate IV*)

This frog, apart from its culinary uses, is of interest because of its voice. Early explorers of the island of Dominica, where it occurs, noted its loud croak coming all night from the woods, not from the water. In addition to this habitual call, which is made with the mouth closed, frogs of this genus can emit a loud scream with widely opened mouths, if they are pursued too closely or captured. This sound is startling in its unexpected pitch, and might surprise the enemy into stopping for a few seconds to see whence it came, or dropping its prey, thus allowing the frog a brief respite in his race with death.

THE HORNED TOAD: Ceratophrys dorsata

(*See Color Plate VIII*)

This toad is peculiar in possessing elongate, pointed teeth, even in the youthful stages. It can inflict a serious bite and will actually attack with opened mouth if disturbed. Even the tadpoles have large mouths and many tooth rows, for they are carnivorous, feeding on the eggs of other frogs.



Photograph by Karl P. Schmidt

HIGHLY ADAPTED FOR ARBOREAL LIFE

The remarkable clasping power of the fingers and toes of tree-toads can be noted in *Hyla infrafrenata,* from Manokuari, Dutch New Guinea. Tree-toads of the family *Hylidæ* are nearly cosmopolitan, being found in all countries except some parts of Africa and Indo-Malayan regions.

The adult is cannibalistic and catches other frogs, as well as mice, small birds, and snails. While a very close relative, *Ceratophrys americana,* secretes a virulent poison from its skin, *Ceratophrys dorsata* is innocuous, though much more brightly colored.

THE OREGON RED-LEGGED FROG: Rana aurora

(*See Color Plate III*)

This delicately proportioned and beautifully colored species is exceedingly shy and wary, and its timidity makes it one of the less conspicuous species in the vivarium, where it prefers to bury itself in the moss in the wettest corner of its cage or to hide under the ferns. When picked up, the males repeatedly give a guttural protesting croak, while the young frogs and females voice their indignation in a high-pitched squeak. Occurring from California north to Vancouver Island, these frogs live in the deep, permanent pools of streams, leading an essentially aquatic existence and seldom going very far from shore into the surrounding forests.

THE COMMON BULLFROG: Rana catesbeiana

(*See Color Plate V*)

The largest of our North American frogs, this species ranges over the region east of the Rocky Mountains, and its sonorous bellowing call may be heard in practically every brook or pond throughout its range. It comes rather late from hibernation, breeding from the last of May into July. Its tadpoles become exceedingly large, measuring six or seven inches from mouth to tailtip before metamorphosis, which does not take place until their second summer. For this reason they make excellent inmates for the aquarium, where they act as scavengers by devouring débris and undesirable algæ, while they do no harm to the fish.

THE GREEN FROG: Rana clamitans

(*See Color Plate I*)

This medium-sized species, like the bullfrog, is widely distributed throughout eastern North America. Its voice is much less in volume than that of the bullfrog, but several singing at once can produce a good chorus, nevertheless. The male green frog can be told from the female by his much larger tympanum, or external eardrum, which makes an enormous disk, considerably wider than the greatest diameter of the eye. The adults of both sexes usually have a conspicuous, brilliant green snout, although the remainder of the body may be more or less obscured by a mottling of brown. Unlike that of the bullfrog, the tadpole completes its metamorphosis in a single season and is not over two inches in length.

THE EDIBLE FROG: Rana esculenta

(*See Color Plate VII*)

For centuries this frog has been of culinary interest in the Eastern Hemisphere, where it occurs in one or another of its several subspecific forms over the whole of Europe, in eastern Asia, and in the northern part of Africa. The male frog has two vocal pouches, one on either side of the throat, which are inflated like little balloons when he is uttering the hoarse call and which lie in loose folds at other times.

While *Rana esculenta* goes through life with a "price on its head," so to speak, because of its common name, "edible frog," it is only one of numerous species whose tender and tasty legs may delight the epicure. In the United States the varieties of amphibians which can be utilized for the dinner table include the common bullfrog (*Rana catesbeiana*), the green frog (*Rana clamitans*), the southern bullfrog or pigfrog (*Rana grylio*), the leopard-frog (*Rana pipiens*), the pickerel-frog (*Rana palustris*), and the Oregon red-legged frog (*Rana aurora*). Only the first-named is marketed in appreciable quantities. The others are too small or too scarce to be of general commercial importance.

THE PICKEREL-FROG: Rana palustris

(*See Color Plate III*)

Similar in size and habits to the leopard-frog (see Color Plate I), this species may be distinguished by the presence of a definite yellow color on the hind legs where they join the body, as well as by the more or less rectangular spots on the back. This frog, together with the other terrestrial species, molts its skin several times a year. Slits appear in the middle of the back and cross the breast, and after a process of humping and jerking the frog manages to pull himself out of his old garment, which he promptly proceeds to swallow! In aquatic frogs the shed skin floats away in large patches without being eaten. The new coat underneath is bright and shining. The pickerel-frog occurs from Hudson Bay to Louisiana and over the eastern United States.

THE WOOD-FROG: Rana sylvatica

(*See Color Plate III*)

The wood-frog merits his name, for he is at home in the forested regions of Canada and northern and eastern United States, while the tadpoles may be found in the deep rain-filled ruts of deserted wagon roads or in the hollows left at the uprooting of big trees blown over by storms. The exquisite orange, salmon-pink, and golden tones of his skin, with the distinctive brown ear-patch covering the sides of his head, make him one of the handsomest of all frogs, as well as serving to conceal him as he hops away among the fallen leaves of his native woodland.

THE SOUTHERN BULLFROG OR PIG-FROG: Rana grylio

(*See Color Plate IV*)

The grunting voice of this species, so unlike that of the common bullfrog, *Rana catesbeiana* (Color Plate V), first directed attention to the presence of this remarkable creature in the swamp lands of the South; but it was so difficult to capture that years elapsed before the scientific collectors could secure specimens to be studied. Pig-frogs live in marshes, lakes, and cypress swamps, in water two or three feet deep, under branches of floating dead trees or other débris, so that it is very difficult to get close enough to capture them by day, although they may be dazzled by the glare of a flashlight at night and thus picked up more easily. In May the eggs are laid in large masses, usually attached to weeds, a single egg mass sometimes measuring over twelve inches across. About three days elapse before the tadpoles hatch out.

THE LEOPARD-FROG: Rana pipiens

(*See Color Plate I*)

Most frogs leap hurriedly into the nearest body of water when alarmed, but the leopard-frog prefers concealment among the long grass. In fact, he is often to be found hopping about in the meadow at quite a distance from any stream. His skin glistens with a metallic iridescence, and he is one of the most beautiful of our native frogs. Especially prominent in this species are the lateral glandular folds, one on each side of the back, from which the secretion of slime to lubricate the skin originates. Since cutaneous respiration assists the lungs, and in some species entirely replaces them, it is necessary that the surface of the body be kept moist at all times. This species is found east of the Rocky Mountains over North America into Mexico.

STALKING THE DRAGON LIZARD ON THE ISLAND OF KOMODO

By W. Douglas Burden

August, 1927

all tests valiantly. She had been made fast to mooring masts, she who loved the liberty of the sky, and had courageously defied the storms in France, in Russia, and in Bering Sea; yet not one single part of her elastic frame had given way. She had defied wind, snow, cold, rain, and fog. Now she lay motionless and helpless on the white snow field.

Only one who had seen that airship come into existence and had lived for 176 hours in her cabin, from Rome to the North Pole, from the Pole to Alaska; only one who had accustomed oneself to consider her as a living thing, could realize how heartless it seemed that it was I who had struck her down, at the triumphant close of her wonderful trip. What bitterness in the cup of joy of our triumph!

Thus ended our stupendous adventure.

THE POLE'S SURRENDER TO MAN

It is interesting to review the history of North Polar explorations in the last 30 years. In the first line of attack have been the Italians, the Americans, and the Norwegians.

In 1893-96 Nansen reached 86° 14′ north; a few years later, in 1900, the Italians, led by the Duke of the Abruzzi, pushing farther, touched 86° 34′. The exploration contest by means of sledges was continued and brought to a victorious end by Peary, the American, who, in 1909, finally reached the Pole.

Later on, when man turned to aërial means to conquer the Arctic secret, we again find Norwegians, Americans, and Italians cordially competing in scientific effort.

Amundsen, in 1925, flies as far as 87° 44′ for Norway; one year later, Byrd, the American, on daring wing, reaches the Pole, and only 48 hours later, our airship retraces the path of the American and also attains the Pole.

And this time the ship designed, built, and prepared in Italy and commanded by an Italian officer was carrying on board all three together—the flags of America, Italy, and Norway. And after having dropped them down at the North Pole, on the threshold of the immense unexplored region, our airship was the first to cross the Polar Sea, reaching the Pacific.

If Italy to-day is proud that her ship and her men have accomplished the first transpolar flight; if we are proud to have bound Italy and America together with an amazing aërial route, the plaudits of the civilized world should also go to Amundsen, the Norwegian, who gave his name and the benefit of his vast Arctic experience to the undertaking; to his modest and capable associate, Lincoln Ellsworth, the American, and to all those who coöperated in the technical and financial organization of the expedition. We of the Italian contingent are especially proud that it was Premier Benito Mussolini who fostered the undertaking and gave for it the ship and the men to command her.

After centuries, the dream of old Italian navigators to reach the Pacific across the north, starting from the Mediterranean, is at last realized. This is why we Italians are very grateful to Norway, that small but glorious country, which with her initiative gave us the opportunity to bind Italy and America together with a most amazing aërial route.

We are happy and proud that all along this aërial route of 8,500 miles across Europe, the Barents Sea, the Polar Sea, the Bering Sea, and Alaska, we carried on the front of our commander's cabin the "fascio littorio," symbol of the old, eternal Rome and of the new Italy.

INDEX FOR JANUARY-JUNE, 1927, VOLUME READY

Index for Volume XLI (January-June, 1927,) of the National Geographic Magazine will be mailed to members upon request.

LOS ANGELES COUNTY MUSEUM OF NATURAL HISTORY

August 19

STALKING THE DRAGON LIZARD ON THE ISLAND OF KOMODO

By W. Douglas Burden

THE following 21 photographs were taken on a scientific expedition of the American Museum of Natural History to the Lesser Sunda Islands in Malaysia. The primary object of this expedition was the quest of the dragon lizards of Komodo, the largest lizards in the world, which were first reported in 1912 by P. A. Ouwens, a Dutch scientist of Buitenzorg, Java.

As there are many interesting problems of a zoögeographic nature to be worked out in this region, general collecting of reptiles and amphibians was an important part of the program.

The Sunda Islands are volcanic, built up from the bottom of the sea by a successive series of flows. The eruptions of lava have arisen along the axis of the Sunda Fold, a great arc in the earth's crust extending for more than 3,000 miles, from Sumatra to the Philippines.

Although Bali, Komodo, and Wetar belong to a single group of islands, the extraordinary differences in the people who inhabit them and in the character of the islands themselves are striking.

In Bali, a luxuriant toyland of coconut groves and paddy fields, we found an erupting volcano, an advanced civilization, and a people remarkable for their beauty and form. From Bali we proceeded on the *S. S. Dog*, an official yacht given to us by the Dutch Colonial Government, to Komodo, the home of the dragon lizards.

Komodo was relatively unexplored, only a few white men having landed there. With its fantastic sky line, its sentinel palms, its volcanic chimneys bared to the stars, it was a fitting abode for the great saurians we had come so far to seek. Deer, wild boar, water buffalo, and game birds were abundant on the island.

THE LARGEST AND OLDEST LIVING LIZARDS

With the use of baits we attracted the giant lizards, which flocked around in considerable numbers, so that we were able to observe their habits, select those which we wanted for a museum group, and catch others alive.

The lizards, which attain a length of 10 feet and a weight of 250 pounds, are known to scientists as *Varanus komodoensis*. They are vicious, carnivorous reptiles, which attack their food much as the great flesh-eating dinosaurs must have done, ripping off great chunks of meat with their sharp, recurved saw-edged teeth and swallowing them whole, bones and all.

The Varanus lizards first appear as a genus in the early Eocene, some sixty million years ago; so that we have here not only the largest, but also the oldest, of living lizards. But Komodo is geologically recent. Thus, an old animal is found on a young island. How did it get there? Whence did it come?

A VISIT TO WETAR

After five weeks of collecting and observing, we proceeded from Komodo to Wetar, situated at the eastern limit of the Lesser Sunda chain. As it arose out of the sea, the island appeared a vast mass of torn and splintered mountains. The central portion is unexplored, and small wonder, for the tumble of jagged peaks presents insurmountable barriers opposing the traveler's way.

Bali was inhabited by Malays practicing the Hindu religion; Komodo by a few Malay convicts exported there by the Rajah of Sumbawa. Wetar, on the other hand, is inhabited by Papuans, who belong to a large group of peoples classified by anthropologists as Oceanic Negroids. The Malays, being a mixture of Mongoloid-Polynesian, have no negroid blood.

At Wetar we camped on the shore, enjoying the luxury of sleeping *à la belle étoile*. Collecting proceeded apace until finally one fine morning we sailed away into the Banda Sea, homeward bound.

We had secured a large collection of reptiles and amphibians. Of the dragon lizards we had 14 specimens, two being alive. The rest were to be used for study purposes and for a mounted group in the new Hall of Reptiles of the American Museum.

Photograph by Mrs. W. Douglas Burden

A COOLIE CLIMBS A GUBBONG, OR LONTAR PALM, ON KOMODO

Everywhere on the island home of the dragon lizard these great trees stand like sentinels along the sky line. Below, in the distance, is Telok Sawa, where the *S. S. Dog*, of the author's scientific expedition (see opposite page), rode at anchor.

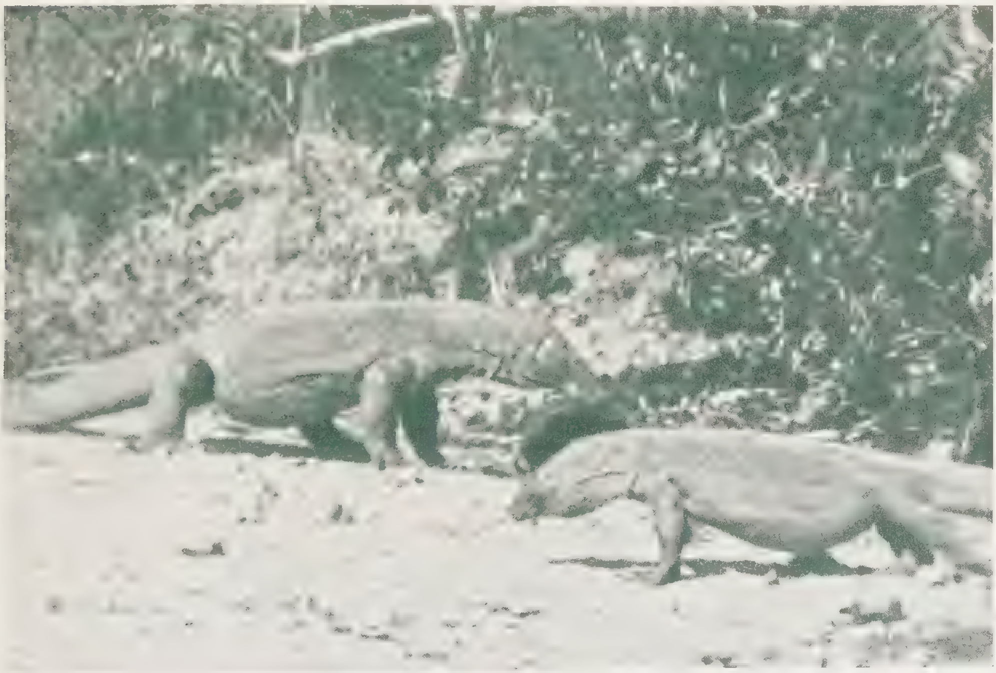
Photograph by W. Douglas Burden

IN THE PINNACLE DISTRICT OF KOMODO

The face of the Komodo landscape belies its true character. When the traveler has forced his way in among the rugged mountains, walking and climbing become very difficult.

A GIANT LIZARD ADVANCING TOWARD THE BAIT

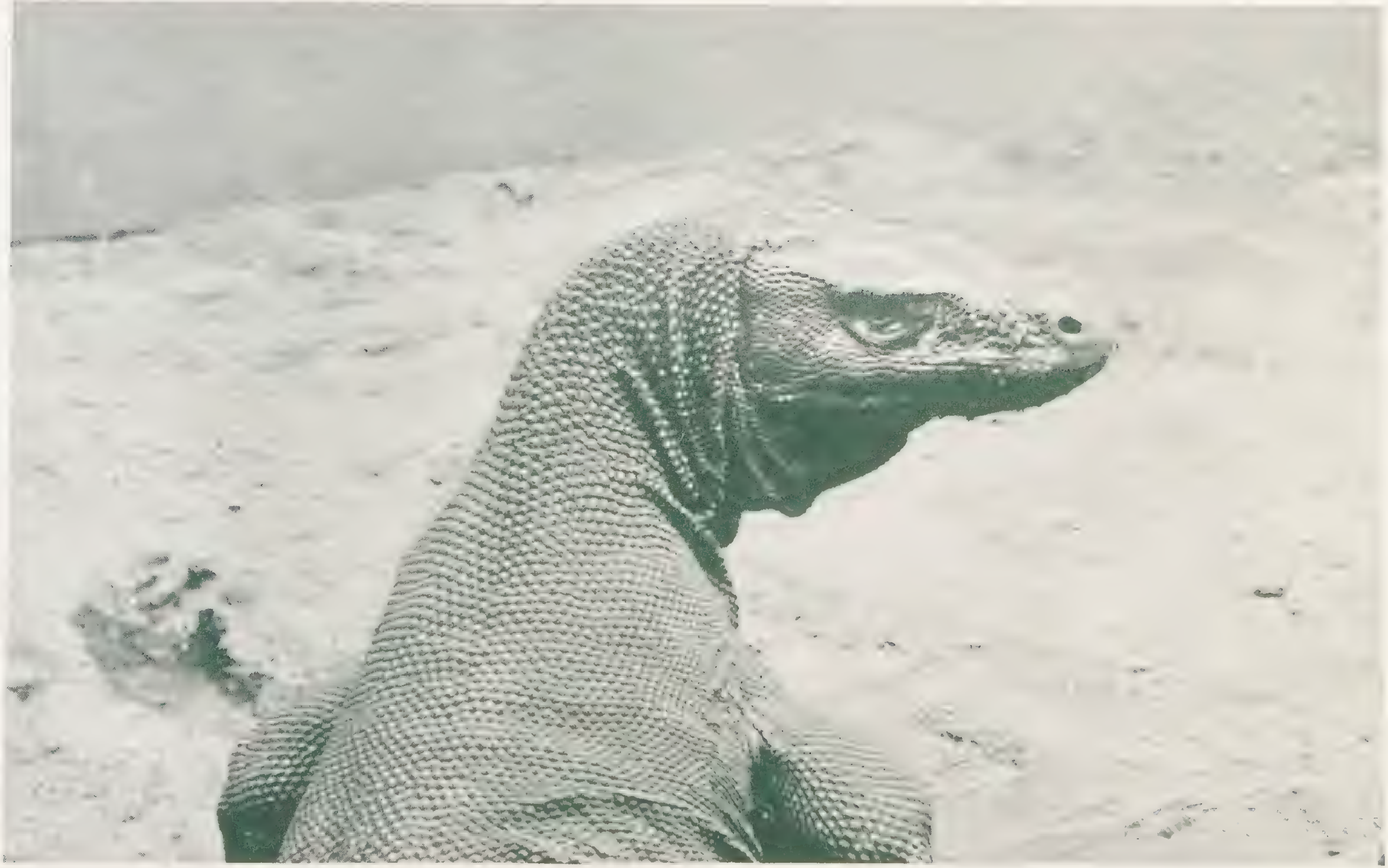
Just so have his ancestors crawled unceasingly through untold millions of years across prehistoric lands.



Photographs by W. Douglas Burden

A LARGE LIZARD ABOUT TO BEGIN FEEDING ON A WILD BOAR CARCASS

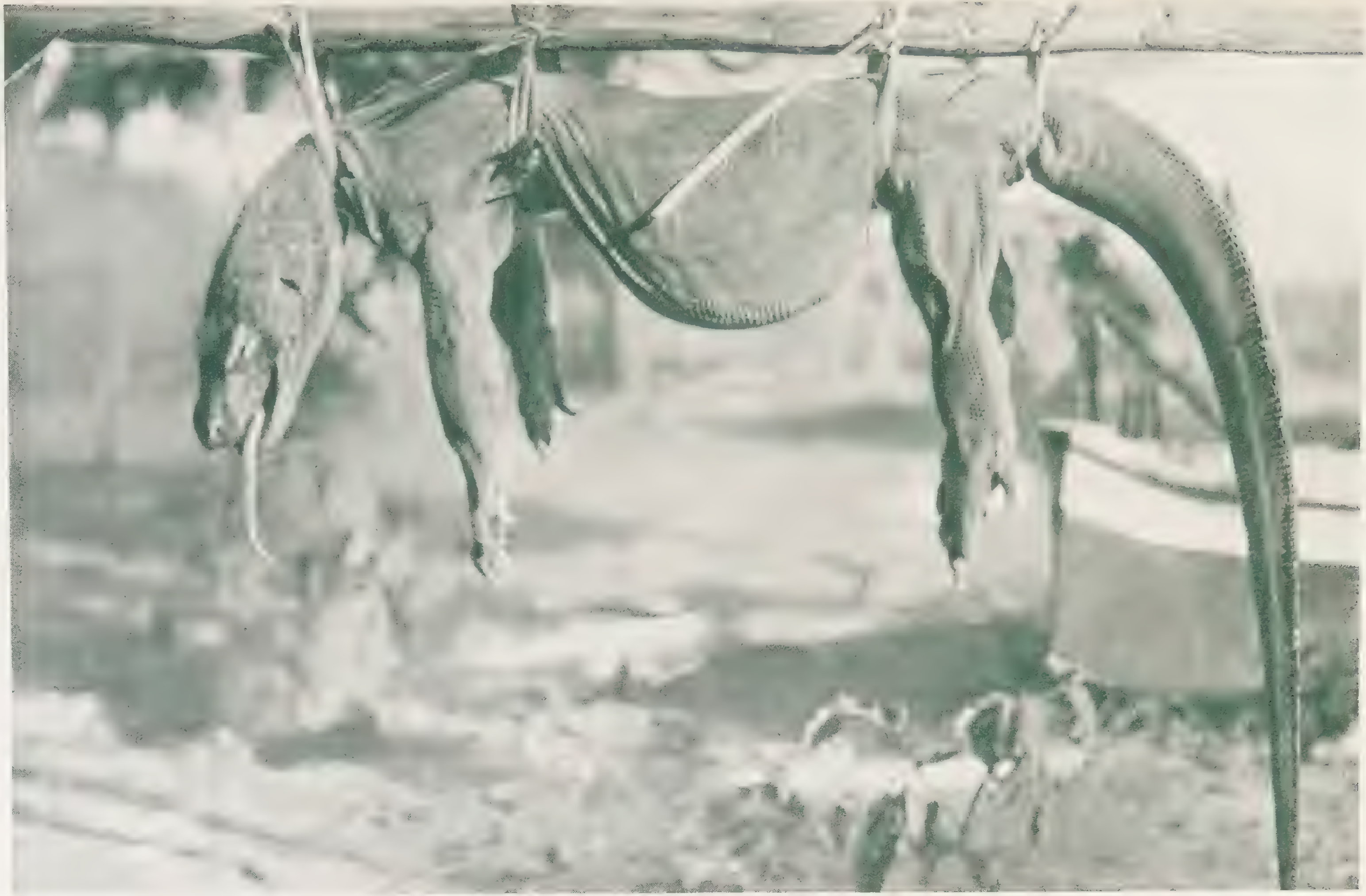
The bait's curling tail can just be distinguished in the illustration below the larger lizard's neck.



Photograph by New York Zoölogical Society

AN EXILE FROM KOMODO

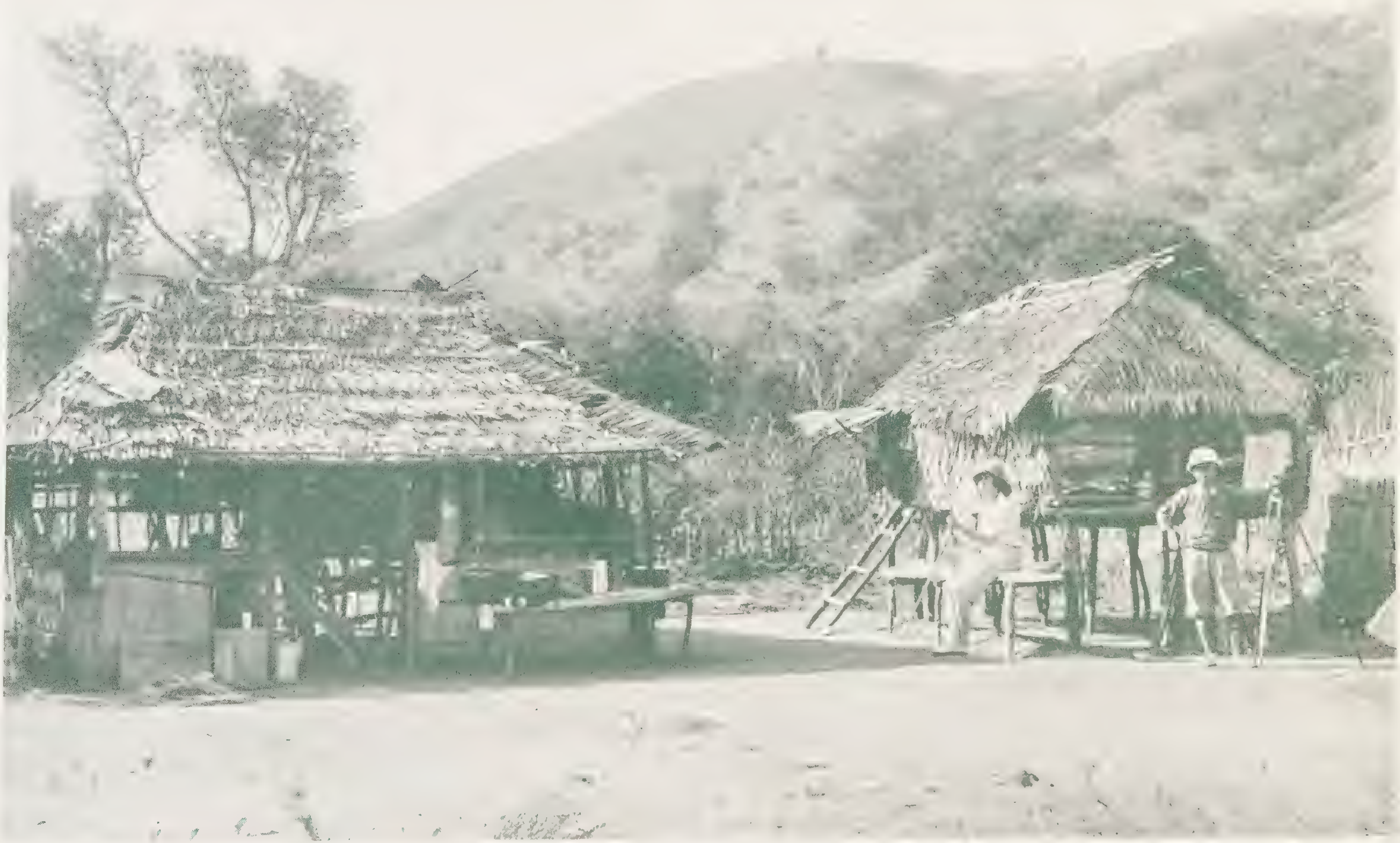
One of the specimens of *Varanus komodoensis* at the New York Zoological Park. Unfortunately, for reasons yet unknown, the big lizards that were brought to the United States alive soon languished and died in captivity.



Photograph by Mrs. W. Douglas Burden

WHEN "VARANUS KOMODOENSIS" IS SHOT HE COLLAPSES LIKE A PRICKED BALLOON

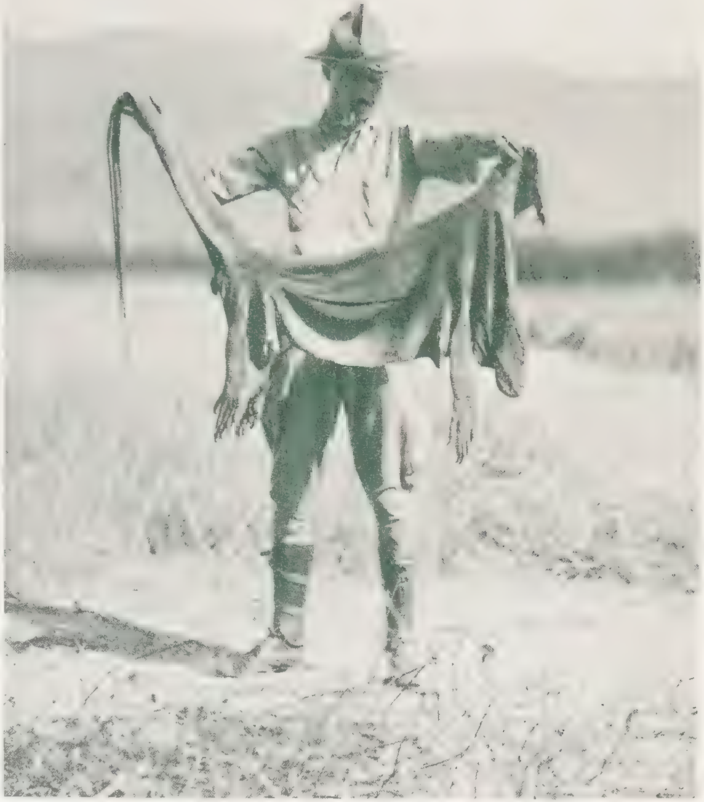
This specimen was a fair-sized lizard, weighing about two hundred pounds.



Photograph by W. Douglas Burden

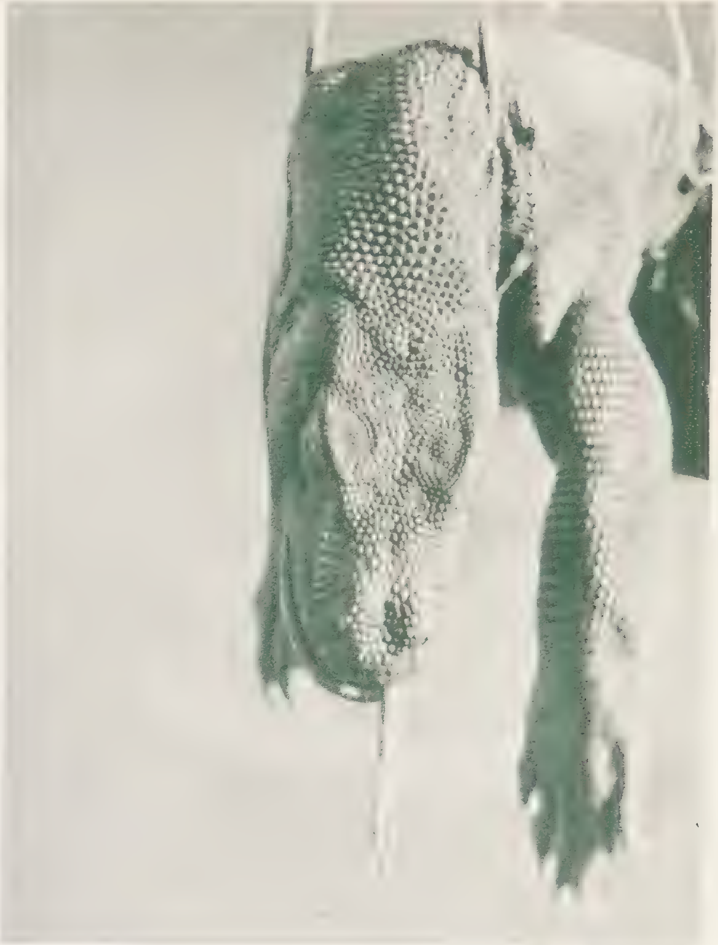
THE EXPEDITION'S FIRST CAMP ON KOMODO

The hut occupied by the author and Mrs. Burden was open to the sea breeze. The roof of woven palm leaves was mellow and bearded with age, and it contained a rich assortment of crawling life, including pit vipers, scorpions, centipedes, and spiders. Indeed, a most interesting collection could have been made from this shelter. To Mrs. Burden's left is Lee Fai, the expedition's cameraman.



READY TO BE MOUNTED AS A MUSEUM SPECIMEN

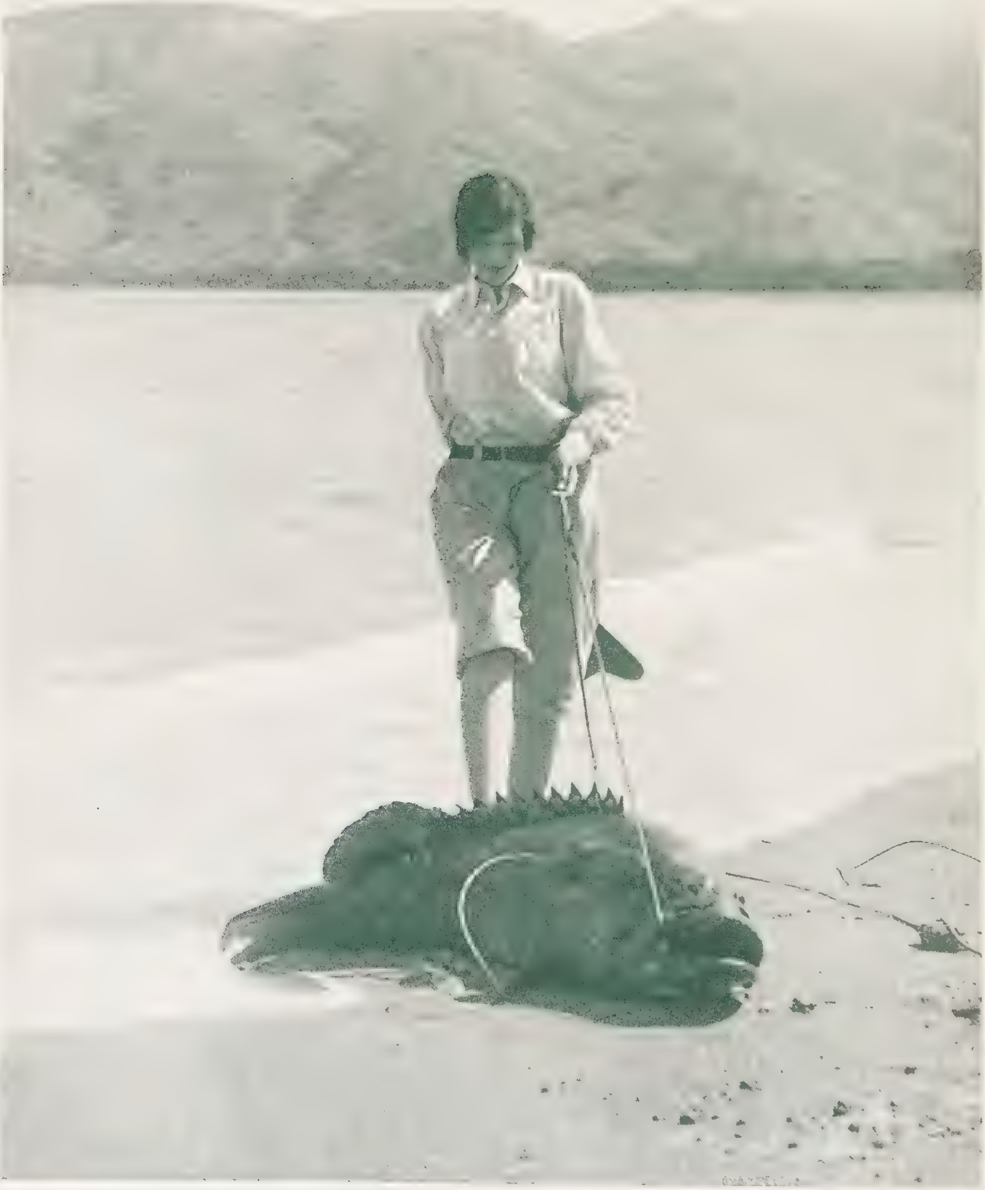
Dr. E. R. Dunn, of Smith College, herpetologist of the Expedition, is holding the skin of a small Komodo lizard.



IN LIFE ITS FORKED TONGUE IS IN ALMOST CONSTANT ACTION

Each scale is underlaid by a plate of bone affording a magnificent armor, which is, however, insufficient protection against bullets.

Photographs by Mrs. W. Douglas Burden



Photograph by W. Douglas Burden

THE SEA YIELDS A MONSTER

Mrs. Burden with a large grouper (*Epinephelus pantherinus*) caught off Komodo. Much of the fishing tackle was lost before manila rope and a leader of chain were adopted. This fish made very good eating.

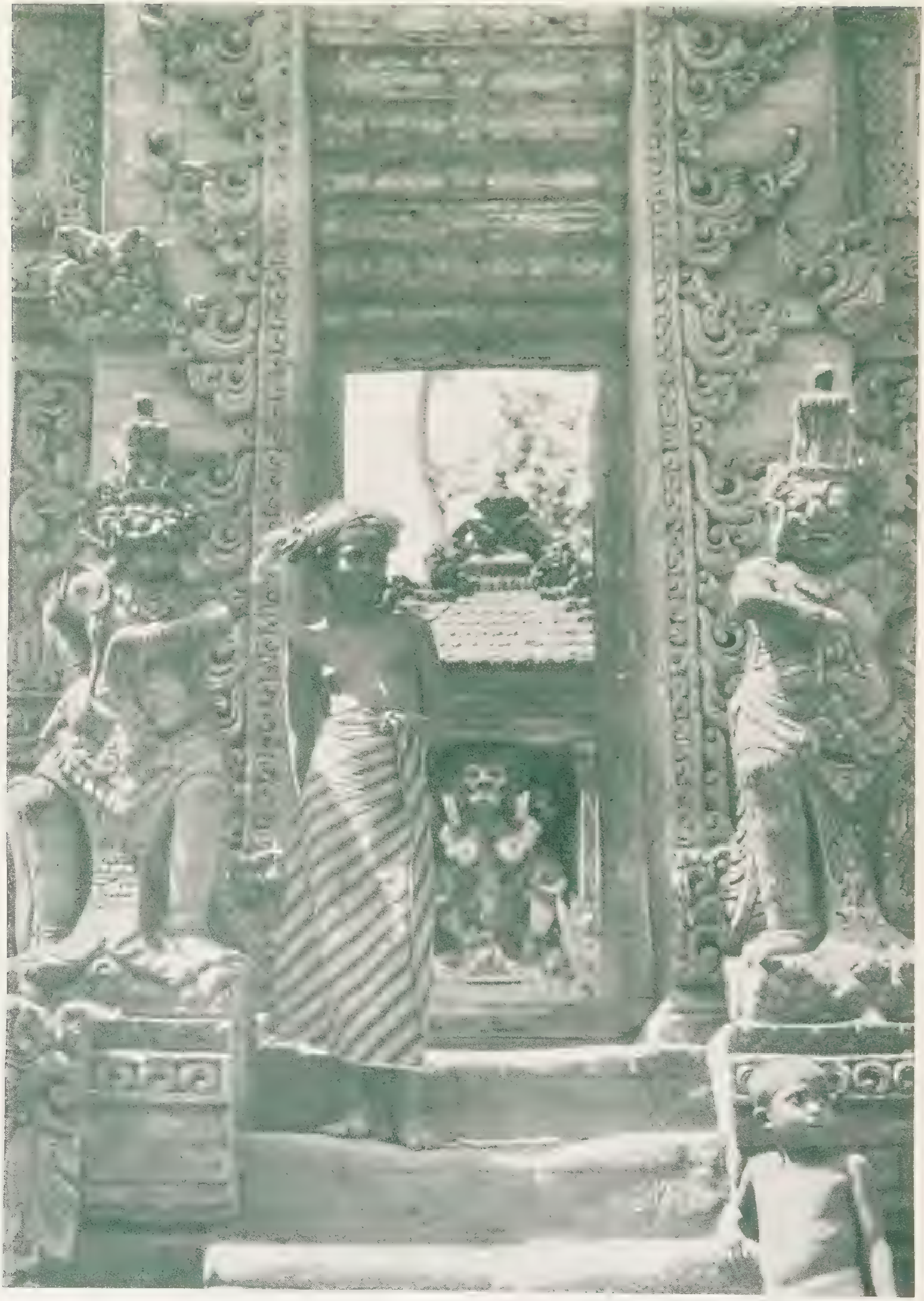
Photograph by W. Douglas Burden

AROUND A CAMP FIRE IN THE JUNGLES OF WETAR

Photograph by Mrs. W. Douglas Burden

A GREEN PIT VIPER ON KOMODO

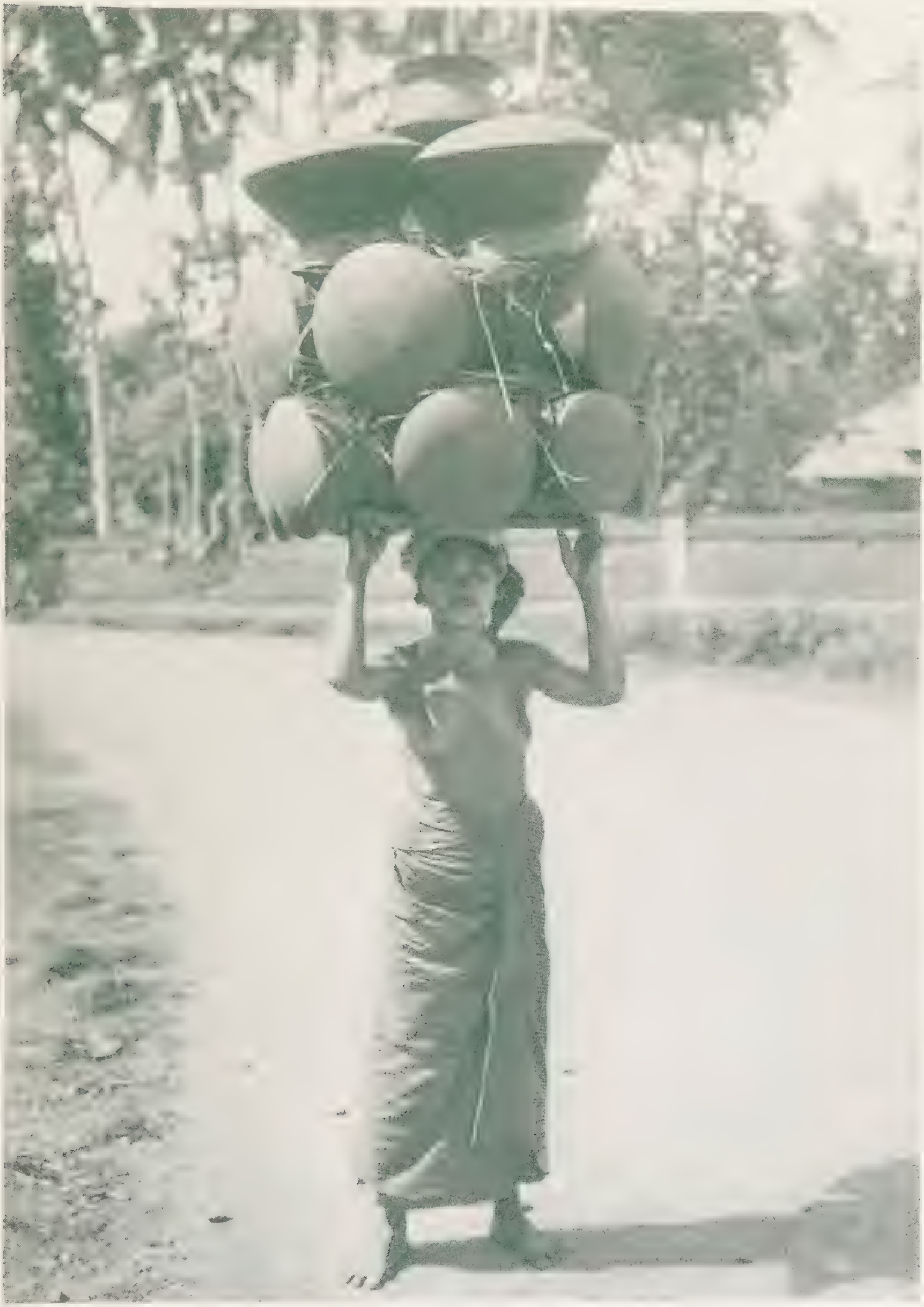
While resting in the grass the coolie felt something wriggling against his skin. Under a fold of his garment he found this venomous creature, *Trimeresurus gramineus,* which he extracted gingerly, with many explosive grunts; then removed its fangs.



Photograph by Mrs. W. Douglas Burden

BALI IS NOTED FOR ITS ORNATE ARCHITECTURE

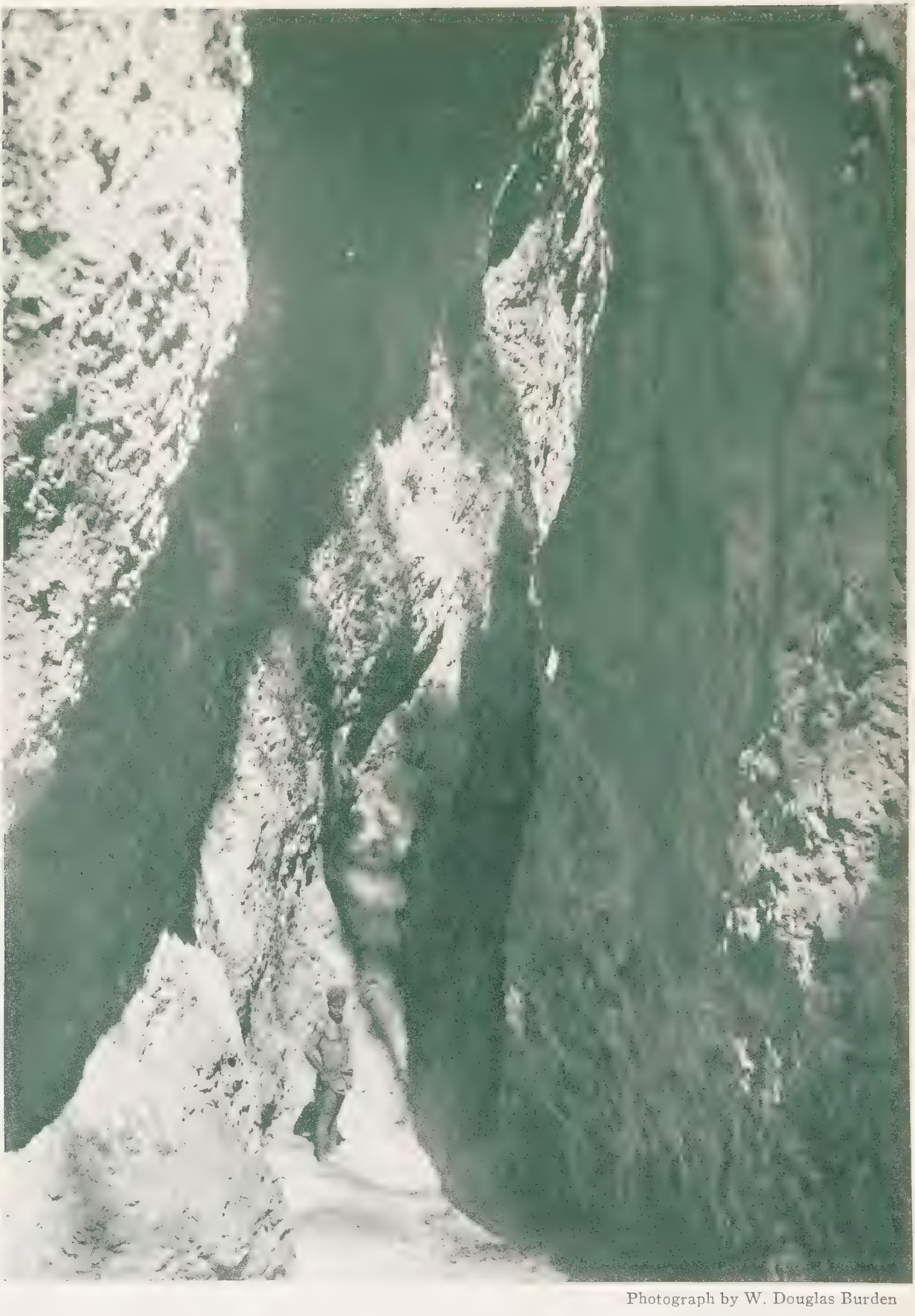
Temple gateways, with their characteristic graven deities, form the most pronounced architectural features of this enchanting island. Bali and Lombok are the only islands in Malaysia where the Hindu religion still holds sway.



Photograph by W. Douglas Burden

A BALINESE WOMAN COOLIE GOES TO MARKET

Beautiful highways connect the important villages of Bali. Along these thoroughfares the natives pour into the market place, which here, as elsewhere in the Orient, is the all-important center for barter.



Photograph by W. Douglas Burden

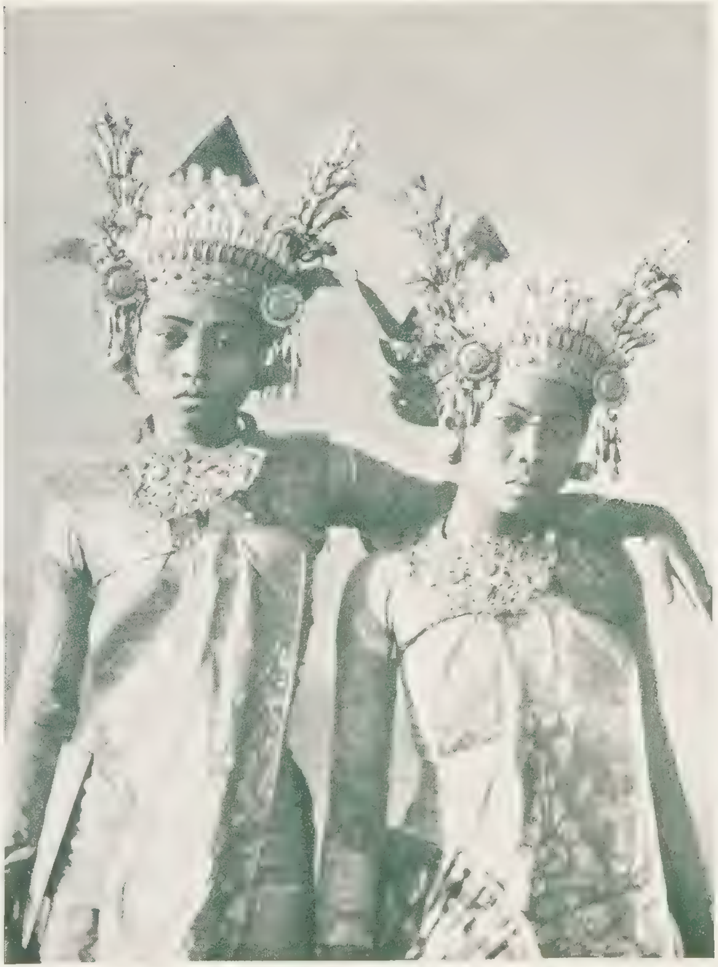
THE EXPEDITION'S PAPUAN GUIDE IN A CANYON OF WETAR

Such canyons, cut vertically out of ancient lava flows, make of the island a well-nigh impassable mass of splintered mountains.

Photograph by W. Douglas Burden

BATHING IN BALI

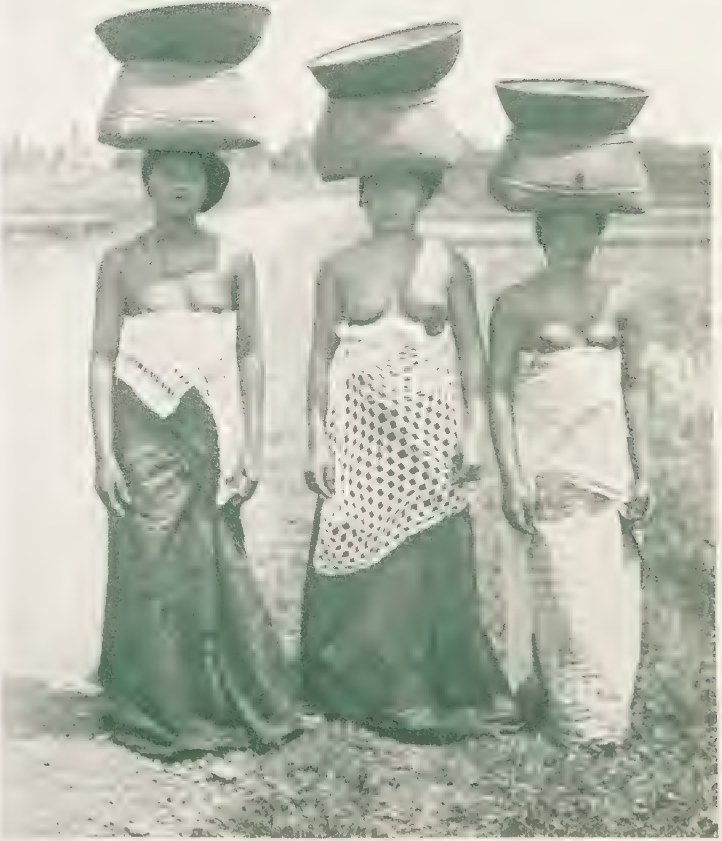
In the evening whole villages come down the leafy paths to watering places. Except for the inevitable sarong, Balinese ladies regard clothes as a mere encumbrance.



Photograph by Mrs. W. Douglas Burden

BALINESE DANCING GIRLS

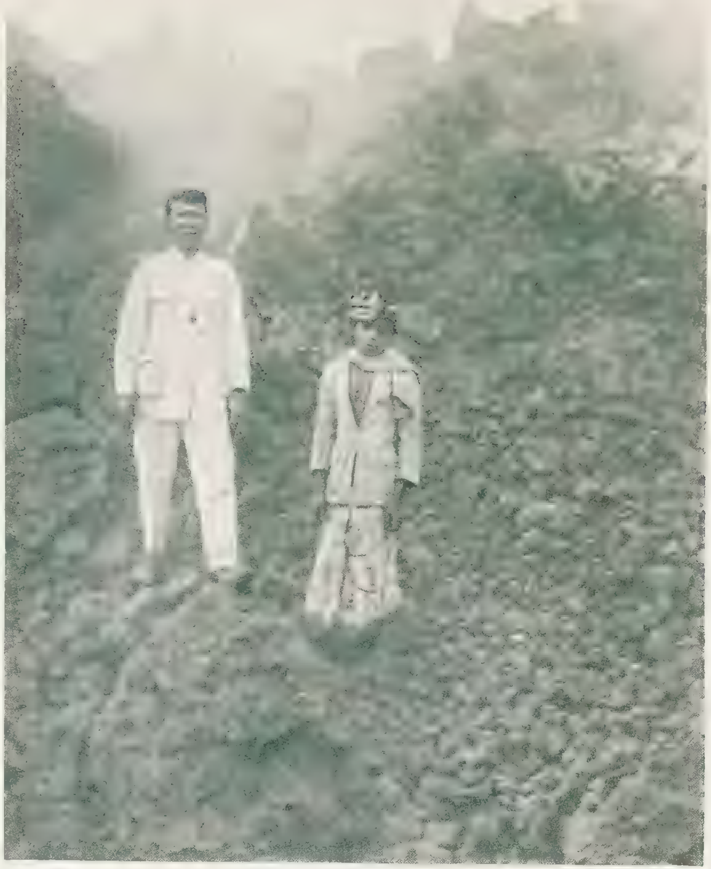
The beautiful brocaded costumes and the golden headdresses crowned with the sacred lotus flower are in striking contrast to the barren, dusty temple yards in which these lithe little dancers perform.



Photograph by W. Douglas Burden

BALINESE COOLIE WOMEN BOUND FOR THE PADDY FIELDS

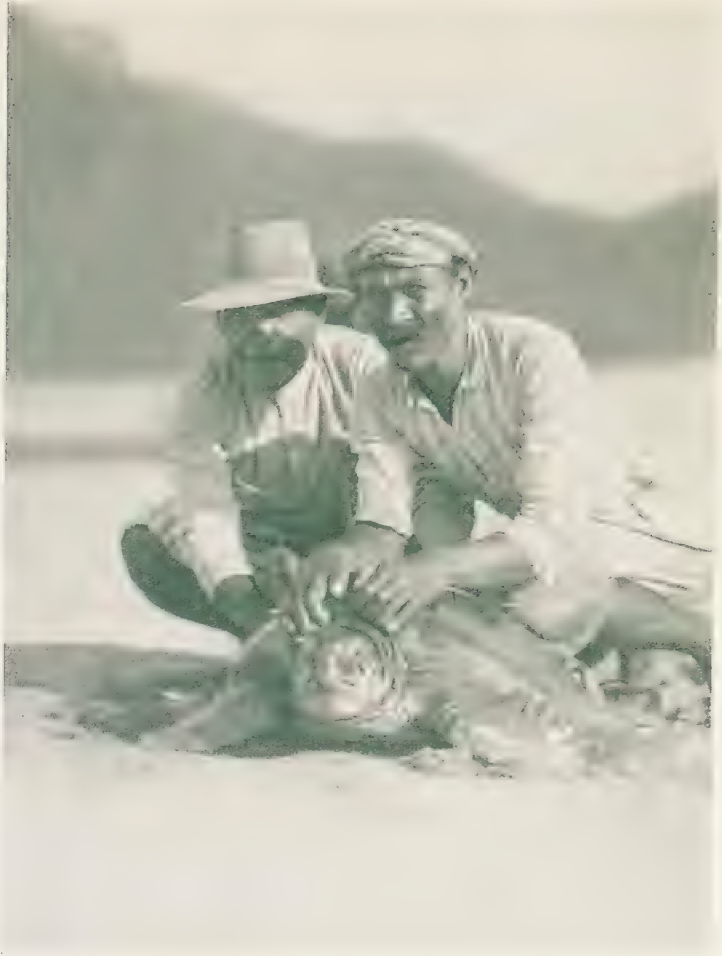
In Bali one never sees the thin, scrawny types of humanity so common in India. There is but slight variation from physical perfection. Everywhere the girls, like plump partridges, adorn the landscape.



Photograph by W. Douglas Burden

THIS LAVA FLOW ON BALI DESTROYED A VILLAGE

When photographed this fresh lava flow, 25 feet high, was still steaming as it rolled relentlessly forward from Batur Volcano. It annihilated the settlement of Batur on the mountain's slopes.



Photograph by Mrs. W. Douglas Burden

CAPTURED BY HAND BENEATH THE WAVES

This green turtle was caught in the sea by Malays, who dived after it, struggled with it under water, and finally emerged with shouts of glee, dragging their prize up on to the beach.

Photograph by W. Douglas Burden

FEEDING A BABY CUSCUS ON WETAR ISLAND

This arboreal, nocturnal, prehensile-tailed marsupial resembles the American opossum. Such little creatures are caught barehanded in the tree tops by the Papuans.

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